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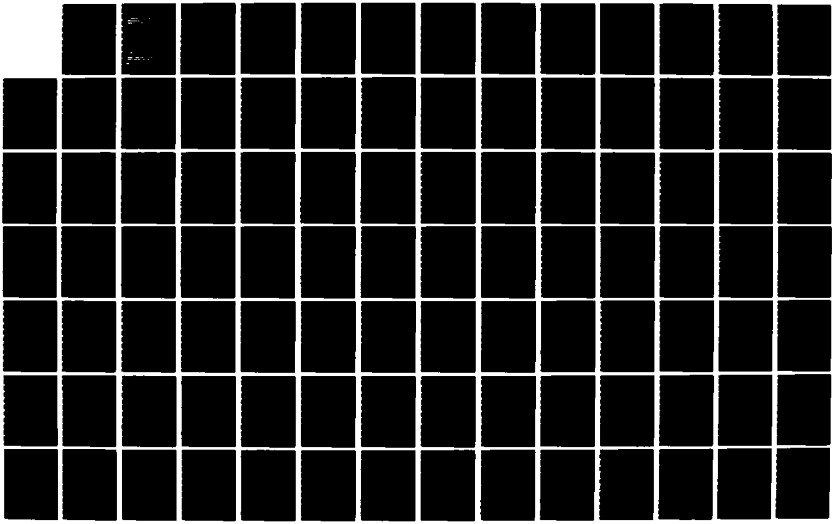

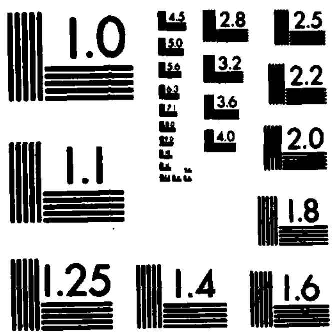

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Connecticut ELF Field-Strength Measurements, May to July 1977

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[illegible] Electromagnetic Systems Department

Naval Underwater Systems Center
Newport, Rhode Island / New London, Connecticut

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Preface

This report was prepared under NUSC Project No. A59007, "ELF Propagation RDT&E" (U), Principal Investigator, P. R. Bannister (Code 3411). Navy Program Element No. 11401N and Project No. X0792-SB, Naval Electronic Systems Command Communications Systems Project Office, D. Dyson (Code PME 110), Program Manager ELF Communications, Dr. B. Kruger (Code PME 110-XI).

The analysis and write up of this report was performed while the author was occupying the Research Chair in Applied Physics at the Naval Postgraduate School, Monterey, CA. The author would especially like to thank Professors Otto Heinz and John Dyer and Dean Bill Tolles for recommending him to occupy this post and NAVSEA (Code 63R) for sponsoring the Chair.

The Technical Reviewer for this report was Raymond F. Ingram.

Reviewed and Approved: 11 January 1984

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From August 1976 to December 1978, extremely low frequency (ELF) field-strength and effective-noise measurements were taken continuously in Connecticut. The results of measurements taken from May through July 1977 are discussed in this report. The principal result is that for the 1-yr period of August 1976 to July 1977 amplitude peak-to-trough variations of 5 dB, or greater, were observed 26 percent of the time.

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TABLE OF CONTENTS

	Page
LIST OF ILLUSTRATIONS	ii
INTRODUCTION	1
CONNECTICUT MAY 1977 MEASUREMENTS	1
CONNECTICUT JUNE 1977 MEASUREMENTS	3
CONNECTICUT JULY 1977 MEASUREMENTS	3
DISCUSSION	4
CONCLUSIONS	6
REFERENCES	16
APPENDIX A — CONNECTICUT DAILY DATA, MAY 1977	A-1
APPENDIX B — CONNECTICUT DAILY DATA, JUNE 1977	B-1
APPENDIX C — CONNECTICUT DAILY DATA, JULY 1977	C-1

LIST OF ILLUSTRATIONS

Figure		Page
1	Connecticut Field Strength Versus GMT, 2 and 3 May 1977	7
2	Connecticut Field Strength Versus GMT, 7 to 9 May 1977	8
3	Comparison of Whip and Loop Field Strengths, 11 May 1977	9
4	Connecticut Field Strength Versus GMT, 13 and 16 May 1977	10
5	Connecticut Field Strength Versus GMT, 4 and 5 June 1977	11
6	Connecticut Field Strength Versus GMT, 7 and 16 July 1977	12
7	Connecticut Field Strength Versus GMT, 18 and 19 July 1977	13
8	Percent of Measurement Days (August 1976 to July 1977) Where the Daily Amplitude Peak-to-Trough Variation Was $\geq$5 dB	14
9	Connecticut Effective Noise Versus GMT Plots for Three Selected Days	15
A-1	Connecticut Data Versus GMT (ψ = 291 deg), 2 May 1977	A-2
A-2	Connecticut Data Versus GMT (ψ = 291 deg), 3 May 1977	A-3
A-3	Connecticut Data Versus GMT (ψ = 291 deg), 4 May 1977	A-4
A-4	Connecticut Data Versus GMT (ψ = 291 deg), 5 May 1977	A-5
A-5	Connecticut Data Versus GMT (ψ = 291 deg), 6 May 1977	A-6
A-6	Connecticut Data Versus GMT (ψ = 291 deg), 7 May 1977	A-7
A-7	Connecticut Data Versus GMT (ψ = 291 deg), 8 May 1977	A-8
A-8	Connecticut Data Versus GMT (ψ = 291 deg), 9 May 1977	A-9
A-9	Connecticut Data Versus GMT (ψ = 291 deg), 10 May 1977	A-10
A-10	Connecticut Data Versus GMT (ψ = 291 deg), 11 May 1977	A-11
A-11	Connecticut Data Versus GMT (ψ = 291 deg), 12 May 1977	A-12
A-12	Connecticut Data Versus GMT (ψ = 291 deg), 13 May 1977	A-13
A-13	Connecticut Data Versus GMT (ψ = 291 deg), 14 May 1977	A-14
A-14	Connecticut Data Versus GMT (ψ = 291 deg), 15 May 1977	A-15
A-15	Connecticut Data Versus GMT (ψ = 291 deg), 16 May 1977	A-16
A-16	Connecticut Data Versus GMT (ψ = 291 deg), 18 May 1977	A-17
A-17	Connecticut Data Versus GMT (ψ = 291 deg), 19 May 1977	A-18
A-18	Connecticut Data Versus GMT (ψ = 291 deg), 20 May 1977	A-19
A-19	Connecticut Data Versus GMT (ψ = 291 deg), 21 May 1977	A-20
A-20	Connecticut Data Versus GMT (ψ = 291 deg), 22 May 1977	A-21
A-21	Connecticut Data Versus GMT (ψ = 291 deg), 23 May 1977	A-22
A-22	Connecticut Data Versus GMT (ψ = 291 deg), 24 May 1977	A-23
A-23	Connecticut Data Versus GMT (ψ = 291 deg), 26 May 1977	A-24
A-24	Connecticut Data Versus GMT (ψ = 291 deg), 27 May 1977	A-25
A-25	Connecticut Data Versus GMT (ψ = 291 deg), 28 May 1977	A-26
A-26	Connecticut Data Versus GMT (ψ = 291 deg), 29 May 1977	A-27
A-27	Connecticut Data Versus GMT (ψ = 291 deg), 30 May 1977	A-28
A-28	Connecticut Data Versus GMT (ψ = 291 deg), 31 May 1977	A-29

LIST OF ILLUSTRATIONS (Cont'd)

Figure		Page
B-1	Connecticut Data Versus GMT (EW Antenna), 2 June 1977	B-2
B-2	Connecticut Data Versus GMT (EW Antenna), 3 June 1977	B-3
B-3	Connecticut Data Versus GMT (EW Antenna), 4 June 1977	B-4
B-4	Connecticut Data Versus GMT (EW Antenna), 5 June 1977	B-5
B-5	Connecticut Data Versus GMT (EW Antenna), 6 June 1977	B-6
B-6	Connecticut Data Versus GMT (EW Antenna), 7 June 1977	B-7
B-7	Connecticut Data Versus GMT (EW Antenna), 8 June 1977	B-8
B-8	Connecticut Data Versus GMT (EW Antenna), 9 June 1977	B-9
B-9	Connecticut Data Versus GMT (EW Antenna), 10 June 1977	B-10
B-10	Connecticut Data Versus GMT (ψ = 291 deg), 11 and 12 June 1977	B-11
B-11	Connecticut Data Versus GMT (ψ = 291 deg), 15 June 1977	B-12
B-12	Connecticut Data Versus GMT (ψ = 291 deg), 16 June 1977	B-13
B-13	Connecticut Data Versus GMT (ψ = 291 deg), 17 June 1977	B-14
B-14	Connecticut Data Versus GMT (ψ = 291 deg), 18 June 1977	B-15
B-15	Connecticut Data Versus GMT (ψ = 291 deg), 19 June 1977	B-16
B-16	Connecticut Data Versus GMT (ψ = 291 deg), 20 June 1977	B-17
B-17	Connecticut Data Versus GMT (ψ = 291 deg), 21 June 1977	B-18
B-18	Connecticut Data Versus GMT (ψ = 291 deg), 22 June 1977	B-19
B-19	Connecticut Data Versus GMT (ψ = 291 deg), 23 June 1977	B-20
B-20	Connecticut Data Versus GMT (ψ = 291 deg), 24 June 1977	B-21
B-21	Connecticut Data Versus GMT (ψ = 291 deg), 30 June 1977	B-22
C-1	Connecticut Data Versus GMT (ψ = 291 deg), 1 July 1977	C-2
C-2	Connecticut Data Versus GMT (ψ = 291 deg), 7 July 1977	C-3
C-3	Connecticut Data Versus GMT (ψ = 291 deg), 8 July 1977	C-4
C-4	Connecticut Data Versus GMT (ψ = 291 deg), 9 July 1977	C-5
C-5	Connecticut Data Versus GMT (ψ = 291 deg), 15 July 1977	C-6
C-6	Connecticut Data Versus GMT (ψ = 291 deg), 16 July 1977	C-7
C-7	Connecticut Data Versus GMT (ψ = 291 deg), 17 July 1977	C-8
C-8	Connecticut Data Versus GMT (ψ = 291 deg), 18 July 1977	C-9
C-9	Connecticut Data Versus GMT (ψ = 291 deg), 19 July 1977	C-10
C-10	Connecticut Data Versus GMT (ψ = 291 deg), 20 July 1977	C-11
C-11	Connecticut Data Versus GMT (ψ = 291 deg), 21 July 1977	C-12
C-12	Connecticut Data Versus GMT (ψ = 291 deg), 22 July 1977	C-13
C-13	Connecticut Data Versus GMT (ψ = 291 deg), 23 July 1977	C-14
C-14	Connecticut Data Versus GMT (ψ = 291 deg), 24 July 1977	C-15
C-15	Connecticut Data Versus GMT (ψ = 291 deg), 25 July 1977	C-16
C-16	Connecticut Data Versus GMT (ψ = 291 deg), 26 July 1977	C-17
C-17	Connecticut Data Versus GMT (ψ = 291 deg), 27 and 28 July 1977	C-18
C-18	Connecticut Data Versus GMT (ψ = 291 deg), 29 July 1977	C-19
C-19	Connecticut Data Versus GMT (ψ = 291 deg), 30 July 1977	C-20
C-20	Connecticut Data Versus GMT (ψ = 291 deg), 31 July 1977	C-21

CONNECTICUT ELF FIELD-STRENGTH MEASUREMENTS, MAY TO JULY 1977

INTRODUCTION

Since June 1970, sporadically we have made farfield extremely low frequency (ELF) horizontal magnetic field-strength measurements in Connecticut.[1-12] The local measurement site from June 1970 to October 1971 was in the Nehantic State Forest, East Lyme, CT. From October 1971 through November 1975, it was located in Hammonassett State Park, Madison, CT. Since July 1976, the AN/BRS-1 ELF receiver has been located at the Naval Underwater Systems Center (NUSC), at New London, CT. The loop receiving antenna is now located at Fishers Island, NY (about 10 km from New London). The receiver and receiving antenna are connected by means of a microwave link from Fishers Island to New London.

The AN/BSR-1 receiver is composed of an AN/UYK-20 minicomputer, a signal timing and interface unit (STIU), a rubidium frequency time standard, two magnetic-tape recorders, and a preamplifier.

The transmission source for these 1.6-Mm range measurements is the U. S. Navy's ELF Wisconsin Test Facility (WTF), located in the Chequamegon National Forest in north-central Wisconsin, about 8 km south of the village of Clam Lake. The WTF consists of two 22.5-km antennas; one antenna is located approximately in the north-south (NS) direction and one is located approximately in the east-west (EW) direction. Each antenna is grounded at both ends. At 76 Hz, the electrical axis of the NS antenna is 14 deg east of north, while the electrical axis of the EW antenna is 114 deg east of north. The WTF array can be steered electrically toward any particular location and its radiated power is approximately 1 W.

In this report, we will discuss the results of the May through July 1977 Connecticut measurements, which were taken to investigate further the diurnal and seasonal ELF propagation variations.

CONNECTICUT MAY 1977 MEASUREMENTS

During this time period, data were obtained on 28 days at the Connecticut site. The daily plots of signal strength, effective noise,* and signal-to-noise ratio (SNR) versus Greenwich Mean Time (GMT) (in 30-min increments) are presented in appendix A. The data are broken up into four time periods, which should be representative of nighttime, sunrise transition period (SRTP), daytime, and sunset transition period (SSTP) propagation conditions. Throughout

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*The effective-noise spectrum level (in dBA/m$\cdot\sqrt{1\ \text{Hz}}$) is defined as the spectrum level of ELF noise at the signal frequency divided by the improvement (in SNR) using nonlinear processing.[13]

this period, the WTF antenna phasing angle (ψ) was 291 deg and the transmitting frequency was 76 ±4 Hz.

As was mentioned in previous reports,[4,7] the Connecticut effective-noise measurements are sometimes contaminated by industrial noise. Thus, the effective-noise values presented here are on the high side.

For a WTF antenna phasing angle of 291 deg, the average Connecticut field strength should equal approximately -143.3 dBA/m during the day and approximately -145.5 dBA/m at night. Referring to figures in appendix A, we see that, with the exception of the nighttime minimum field-strength period, the average field-strength levels are about as expected.

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 5 of the 27 measurement days that included a nighttime measurement period (3, 9, 11, 13, and 16 May). The largest variation (~8.5 dB) occurred on 16 May. These variations are illustrated in figures 1 through 4 and in appendix A.

Referring to figure 1,* we see that the signal strength steadily decreased ~5 dB from the start of the SSTP (0000) to 0430 and, then, steadily increased ~5 dB from 0430 to the end of the SRTP (1030). Meanwhile, the nighttime relative phase decreased ~20 deg from 0430 to 0530. The relative phase then steadily increased ~15 deg by 0900, and then decreased to its normal daytime level by 1030.

The 7 through 9 May field strengths are plotted versus GMT in figure 2. Here, we see that the 7 and 8 May 2000 to 2400 daytime field strengths were approximately 1.5 dB lower than those measured during the rest of the daytime measurement period.

During 7 May, the nighttime field strength was essentially constant, while the 0230 to 0530 nighttime field strengths on 8 May were ~1 dB higher than the average. On 9 May, the field strength steadily decreased ~3 dB throughout the nighttime measurement period, then rapidly increased ~5 dB during the SRTP. The night-to-day relative-phase variation was ~30 deg on 7 May and ~25 deg on 8 May. During 9 May, the nighttime relative phase decreased ~15 deg from 0400 to 0530 and increased ~15 deg from 0530 to 0630.

On a few occasions, we have also measured the vertical-electric field strength (E_V) produced by the WTF. Presented in figure 3 is a comparison of the horizontal-magnetic and vertical-electric field strengths during 11 May. We see that the nighttime field strengths measured on both antennas steadily decreased ~3 dB from 0230 to 0530. Then, the field strengths steadily increased 5 to 6 dB from 0530 to the end of the SRTP (1030). Meanwhile, both the horizontal-magnetic and vertical-electric nighttime relative phase decreased 20 to 25 deg from 0500 to 0700.

The 13 and 16 May field strengths are plotted in figure 4 versus GMT. We can see that on 13 May the field strength steadily decreased ~3 dB during the nighttime measurement period and, then, rapidly increased ~5 dB by 1200. Meanwhile, the nighttime relative phase increased ~20 deg from 0230 to 0630, then decreased ~20 deg by 0830.

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*Figures have been placed together at the end of this report or in the applicable appendix.

During 16 May, the nighttime field strength rapidly decreased ~5 dB from 0230 to 0330, remained fairly constant (and low level) until 0500, then increased ~4 dB from 0500 to 0630. During the SRTP, the field strength increased ~4.5 dB, resulting in a daily peak-to-trough variation of ~8.5 dB! The relative phase gradually increased ~10 deg during the nighttime measurement period and the average night-to-day relative-phase variation was ~30 deg.

CONNECTICUT JUNE 1977 MEASUREMENTS

During this time period, data were obtained on 21 days at the Connecticut site. The daily plots of signal strength, effective noise, and SNR versus GMT (in 30-min increments) are presented in appendix B. From 2 through 10 June, only the WTF EW antenna was energized. During the rest of the month, the WTF antenna phasing angle was 291 deg. The transmitting frequency was 76 ±4 Hz.

For a WTF antenna phasing angle of 291 deg, the average Connecticut field strength should equal ~-143.3 dBA/m during the day and ~-145.5 dBA/m at night. When only the WTF EW antenna is energized, the Connecticut field strengths should be approximately 1 dB lower. Referring to appendix B, we see that, with the exception of the nighttime minimum field-strength period, the average field-strength levels are about as expected.

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during none of the 21 days that included a nighttime measurement period. The largest variation (~4.5 dB) occurred on 4 and 5 June. This is further illustrated in figure 5. During 4 June, the field strength gradually decreased ~2 dB during the nighttime measurement period (0300 to 0730) and steadily increased ~4.5 dB during the SRTP. Meanwhile, the relative phase gradually increased ~10 deg during the nighttime measurement period and the average night-to-day relative phase variation was ~25 deg.

On 5 June, the field strength rapidly decreased ~3 dB at the beginning of the SSTP, gradually increased during the nighttime measurement period, and rapidly increased ~2.5 dB around the middle of the SRTP. The average nighttime field strength was approximately 1 dB higher than normal. Meanwhile, the relative phase decreased ~15 deg at the beginning of the SSTP, increased ~25 deg by the end of the SSTP, and gradually increased ~10 deg during the nighttime measurement period. The average night-to-day relative-phase variation was ~20 deg.

CONNECTICUT JULY 1977 MEASUREMENTS

During this time period, data were obtained on 20 days at the Connecticut site. The daily plots of signal strength, effective noise, and SNR versus GMT (in 30-min increments) are presented in appendix C. Throughout this period, the WTF antenna phasing angle (ψ) was 291 deg and the transmitting frequency was 76 ±4 Hz.

As we previously mentioned, for ψ = 291 deg, the average Connecticut field strength should equal ~-143.3 dBA/m during the day and ~-145.5 dBA/m at

night. Referring to appendix C, we see that, with the exception of the minimum nighttime field-strength period, the average field-strength levels are about as expected.

Amplitude peak-to-trough variations of 5 dB, or greater, occurred during 4 of the 19 measurement days that included a nighttime measurement period (7, 16, 18, and 19 July). The largest variation (~7 dB) occurred on 16 and 19 July. These variations are further illustrated in figures 6 and 7.

Referring to figure 6, we see that the 7 July signal strength steadily decreased ~5 dB from 2230 to 0430 and steadily increased ~5 dB from 0430 to 1000. The nighttime relative phase steadily increased ~15 deg from 0230 to 0700 and the average night-to-day relative-phase variation was ~30 deg.

During 16 July (figure 6), the signal strength steadily decreased ~6.5 dB from midnight to 0600 and steadily increased ~6 dB from 0600 to 1200. The average night-to-day relative-phase variation was 25 to 30 deg.

Referring to figure 7, we see that, on 18 July, the field strength decreased ~3 dB during the SSTP, remained essentially constant from 0130 to 0500, decreased ~2.5 dB by 0700, and steadily increased ~5.5 dB from 0700 to 1300. The nighttime relative phase increased ~15 deg from 0230 to 0600 and decreased ~30 deg by 0800. The average night-to-day relative-phase variation was ~20 deg.

During 19 July (figure 7), the field strength steadily decreased ~7 dB from midnight to 0800, then very rapidly increased ~4.5 dB by 0930. The average night-to-day relative-phase variation was ~30 deg. Note that, during both 18 and 19 July, the nighttime relative phase was maximum about 0.5 to 1 hr earlier than the minimum nighttime field-strength amplitude time. This occurrence is consistent with previous results.[6,7,14,15]

DISCUSSION

During the last several years, we have made a substantial number of horizontal magnetic field-strength measurements in Connecticut. We definitely noticed that ELF nighttime propagation is much more variable than ELF daytime propagation. Two prime candidates for the cause of these nighttime variations are particle precipitation and the presence of a nocturnal sporadic-E layer.[14,15]

Presented in table 1 are the number of August 1976 to July 1977 Connecticut measurement days (that included a nighttime measurement period) where the daily amplitude peak-to-trough variation was 5 dB, or greater. The monthly percentage of these days (relative to the total number of measurement days) is also shown in table 1 and is plotted in figure 8.

Referring to table 1 and figure 8, we see that, for the 1-yr period of August 1976 to July 1977, 5 dB or greater signal-strength fades occurred during 26 percent of the measurement days. The most frequent nighttime fading

Table 1. Number of Connecticut Measurement Days (That Included a Nighttime Measurement Period) Where the Daily Amplitude Peak-to-Trough Variation Was $\geq$5 dB

Month	Number of Days	Total Number of Measurement Days	Percent
August 1976	3	11	27
September 1976	9	20	45
October 1976	6	25	24
November 1976	0	25	0
December 1976	2	27	7
January 1977	11	27	41
February 1977	10	28	36
March 1977	14	29	48
April 1977	9	25	36
May 1977	5	27	19
June 1977	0	21	0
July 1977	4	19	21
Total for 1-yr Period	73	284	26

occurred during the late-winter/early-spring (January through April) and late-summer/early-fall (September) periods. The least frequent nighttime fading occurred during June and November/December.

Presented in figure 9 are plots of the measured Connecticut effective noise for three separate days (one each in May, June, and July). The diurnal variation was ~9 dB on 3 May, ~13 dB on 22 June, and ~18 dB on 21 July, with the minimum values occurring during the 0800 to 1200 GMT period (around local sunrise), and the maximum values occurring during the 2000 to 2400 period (before local sunset). These maximum and minimum time periods are consistent with worldwide thunderstorm activity.

As we mentioned previously, the Connecticut effective-noise measurements are sometimes contaminated by industrial noise. Thus, the effective-noise values measured are on the high side. Effective-noise values less than -144 dBH are very seldom measured in Connecticut, although these low values have often been measured at sea and at other land sites.

The noisiest period of the year in Connecticut is from 2000 to 2400 GMT during July. During this period, the effective noise is greater than -130 dBH 50 percent of the time and greater than -124 dBH 5 percent of the time. These abnormally high effective-noise values (>-129 dBH) have not been measured anywhere else on land or at sea.

CONCLUSIONS

The horizontal magnetic field-strength measurements taken in Connecticut from May through July 1977 again have demonstrated that the short-term sample-to-sample variability of ELF nighttime propagation is much greater than the short-term sample-to-sample variability of ELF daytime propagation.

For the 1-yr period of August 1976 to July 1977, amplitude peak-to-trough variations of 5 dB, or greater, were observed 26 percent of the time. The most frequent nighttime fading occurred during the late-winter/early-spring (January through April) and late-summer/early-fall (September) periods. The least frequent nighttime fading occurred during June and November/December.

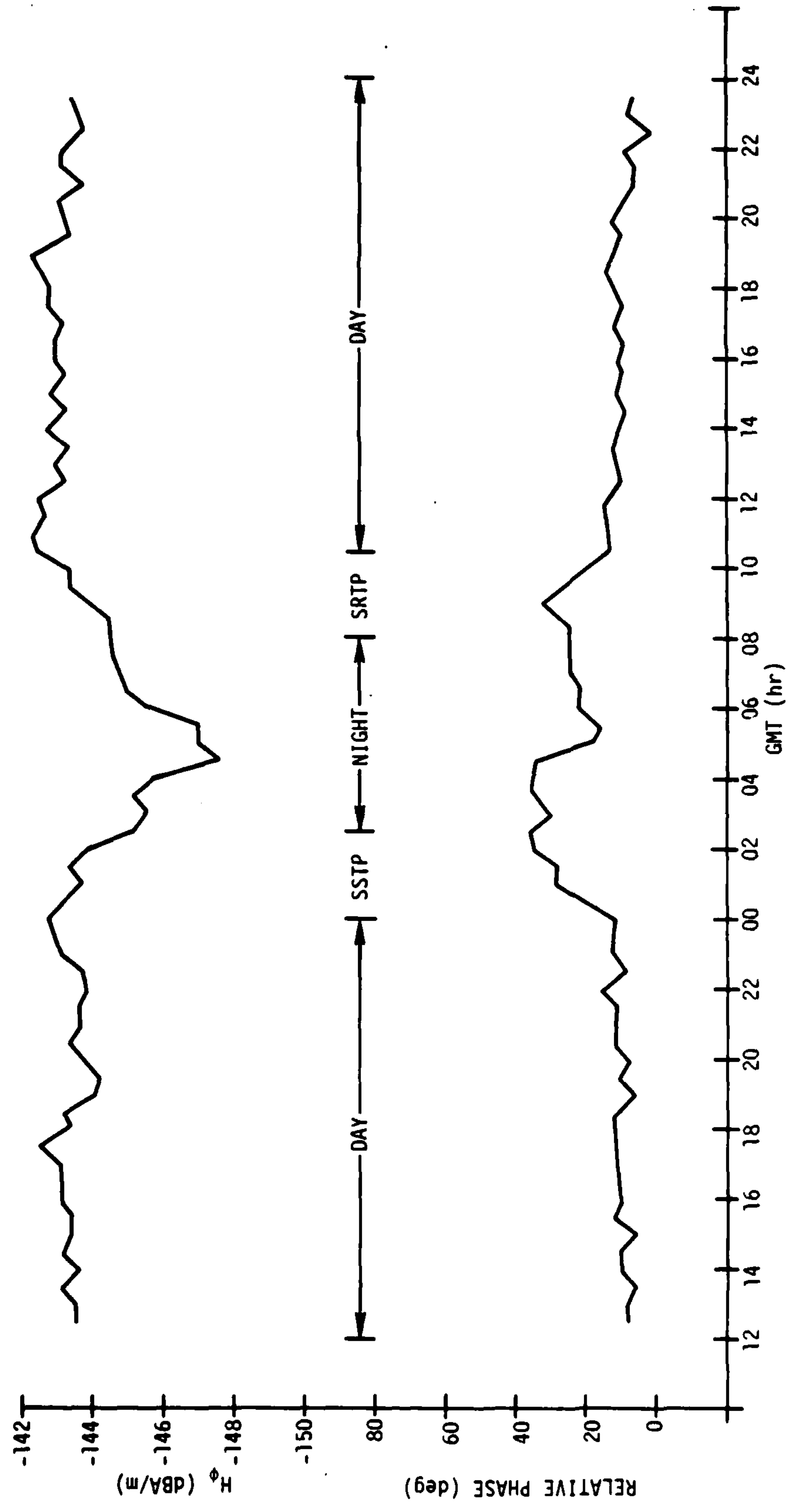

Figure 1. Connecticut Field Strength Versus GMT, 2 and 3 May 1977

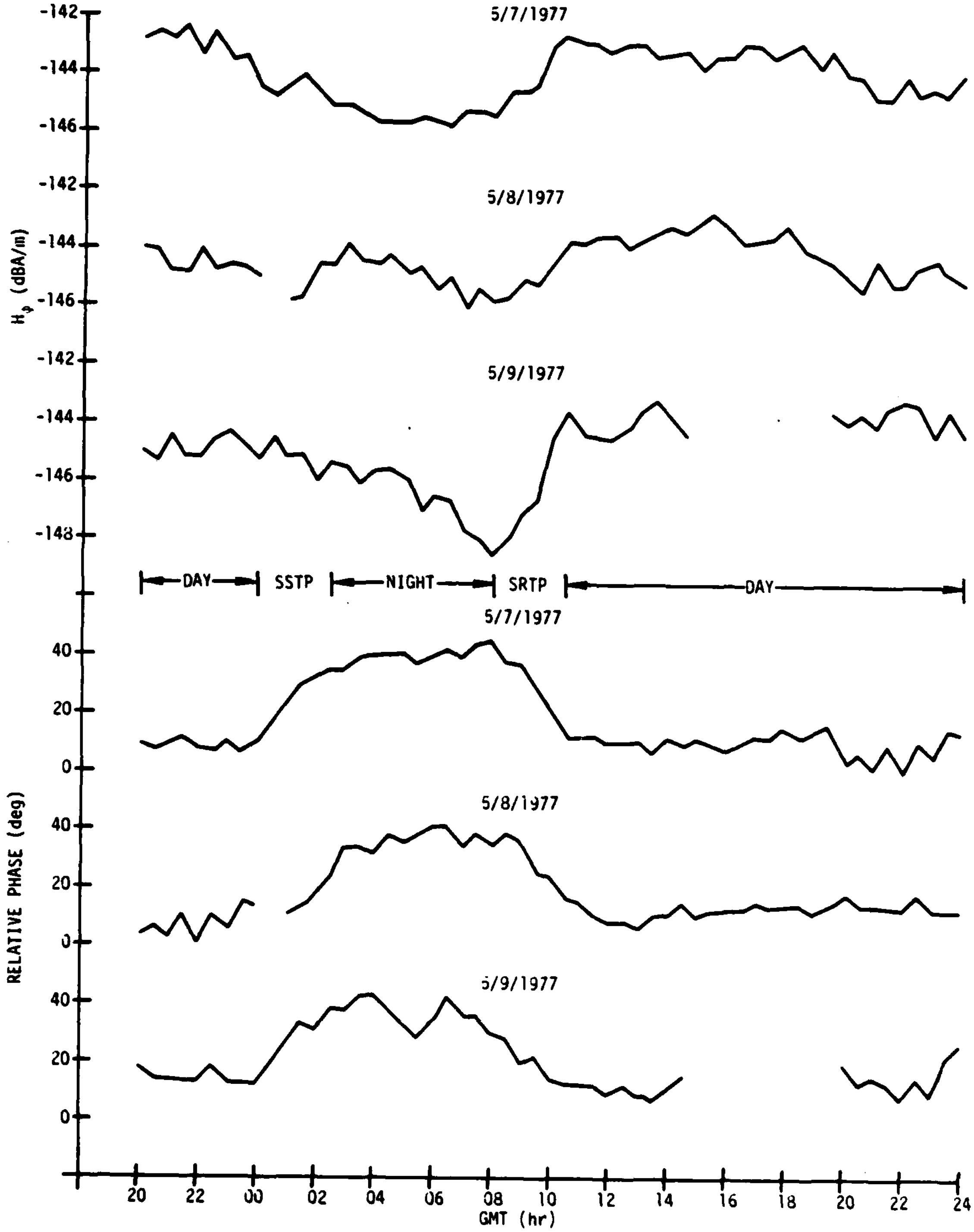

Figure 2. Connecticut Field Strength Versus GMT, 7 to 9 May 1977

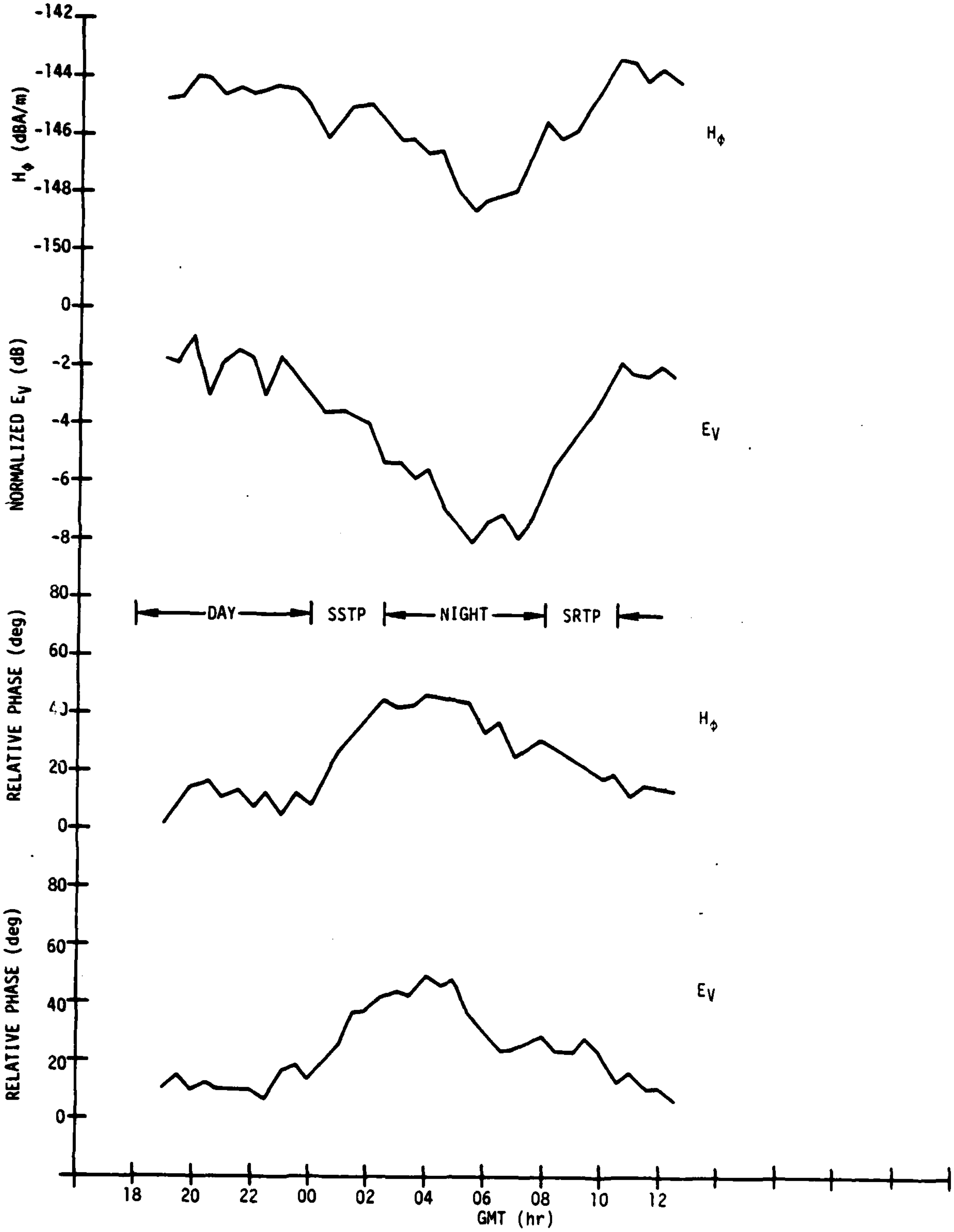

Figure 3. Comparison of Whip and Loop Field Strengths, 11 May 1977

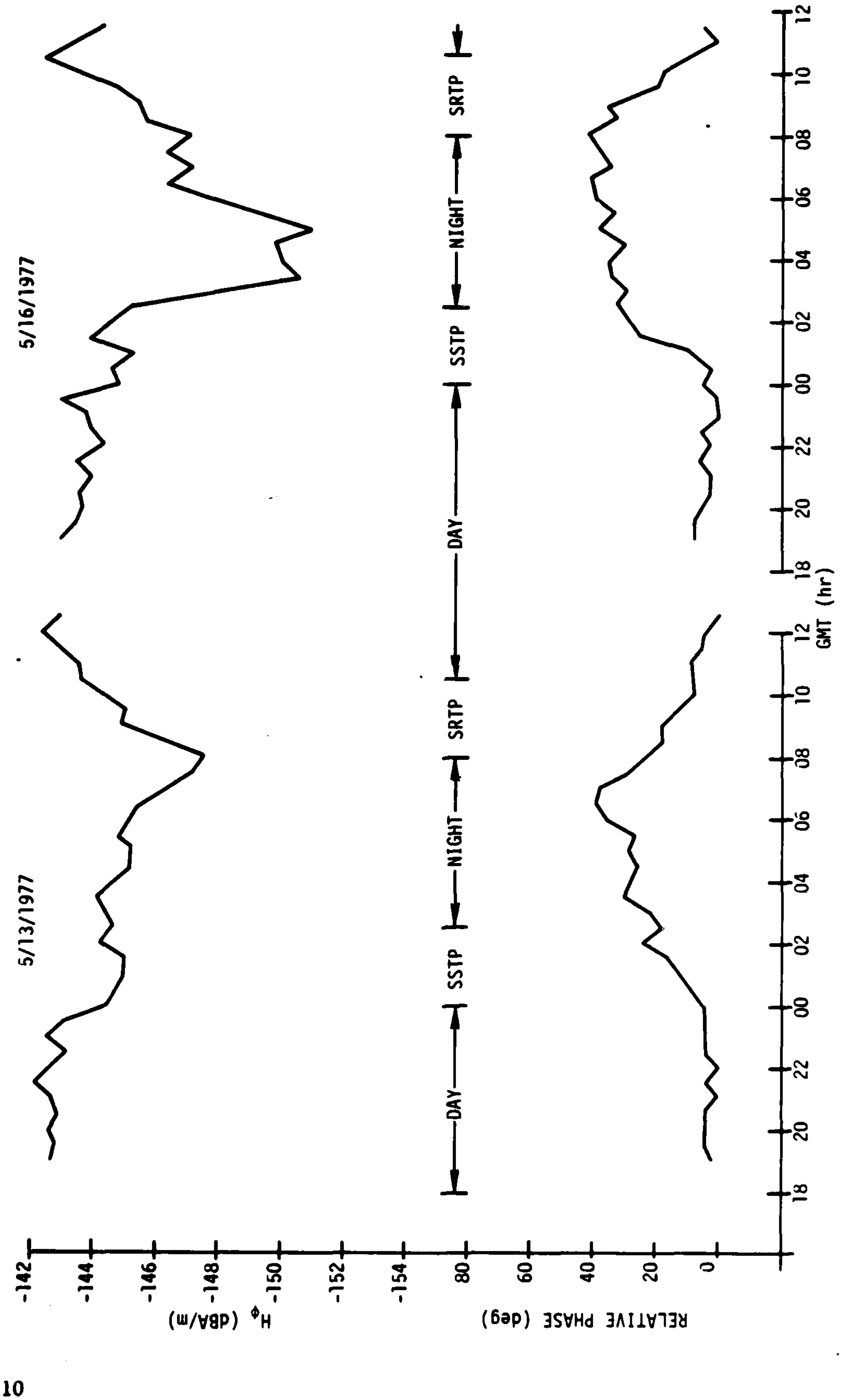

Figure 4. Connecticut Field Strength Versus GMT, 13 and 16 May 1977

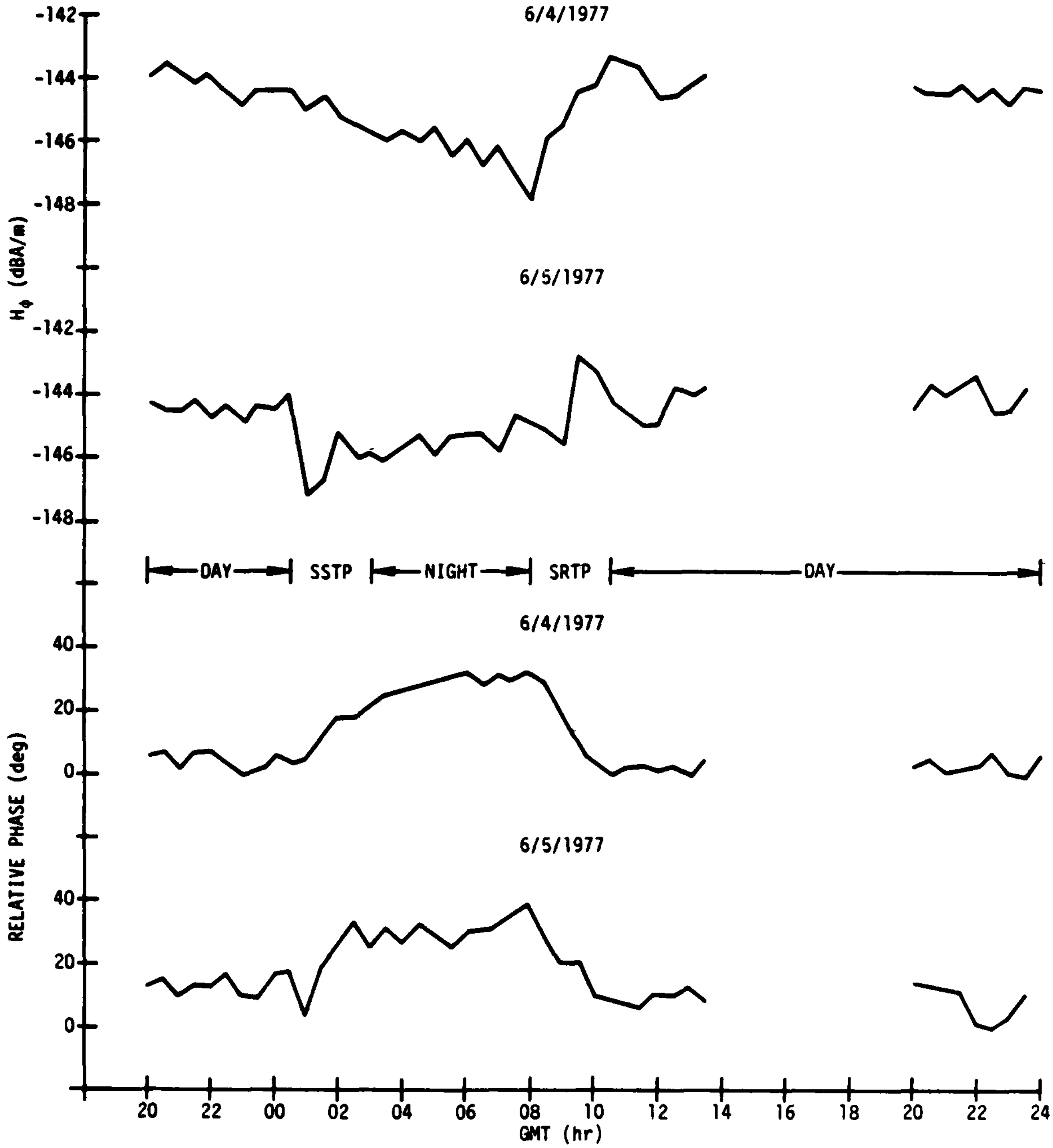

Figure 5. Connecticut Field Strength Versus GMT,
4 and 5 June 1977

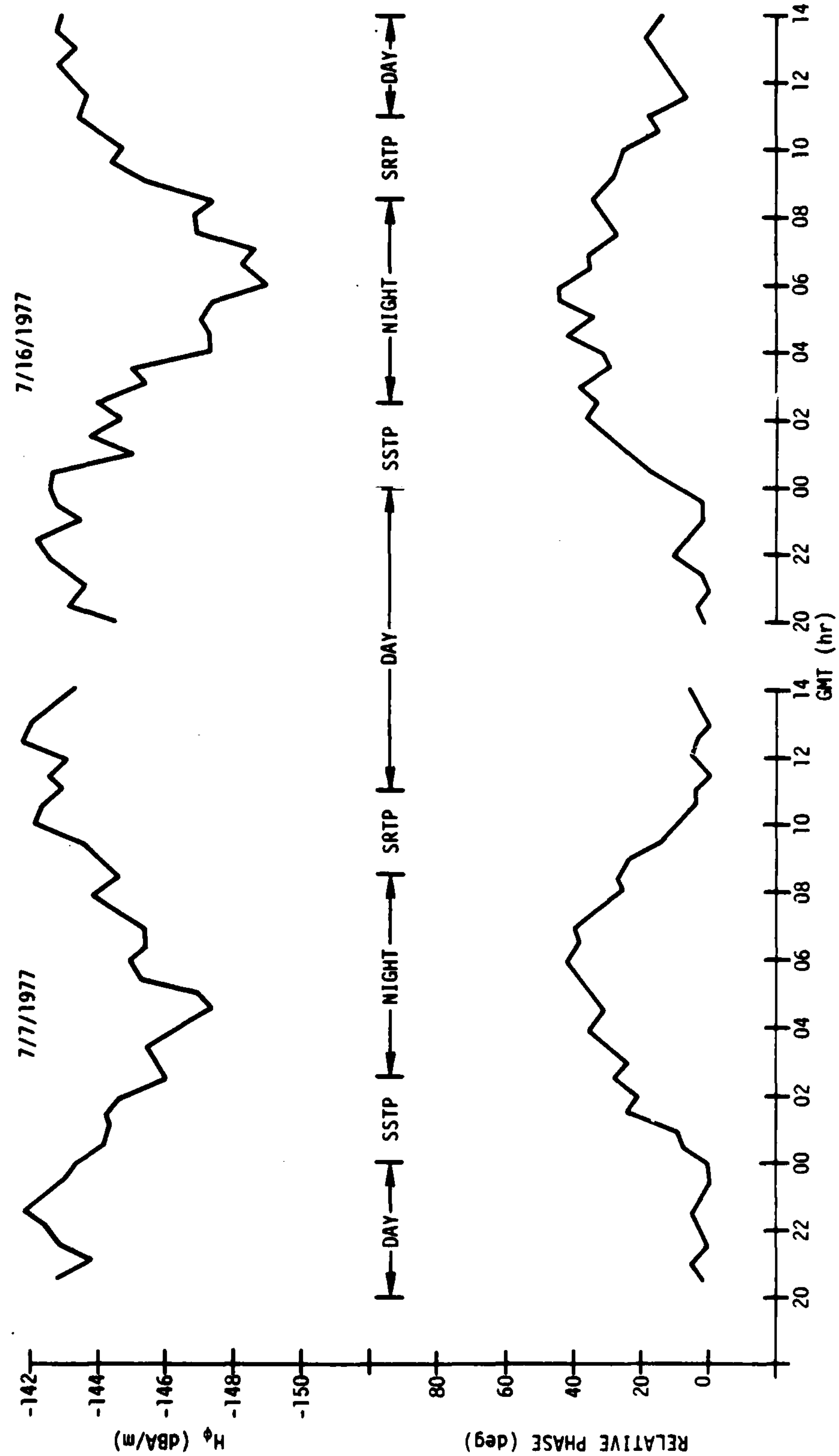

Figure 6. Connecticut Field Strength Versus GMT, 7 and 16 July 1977

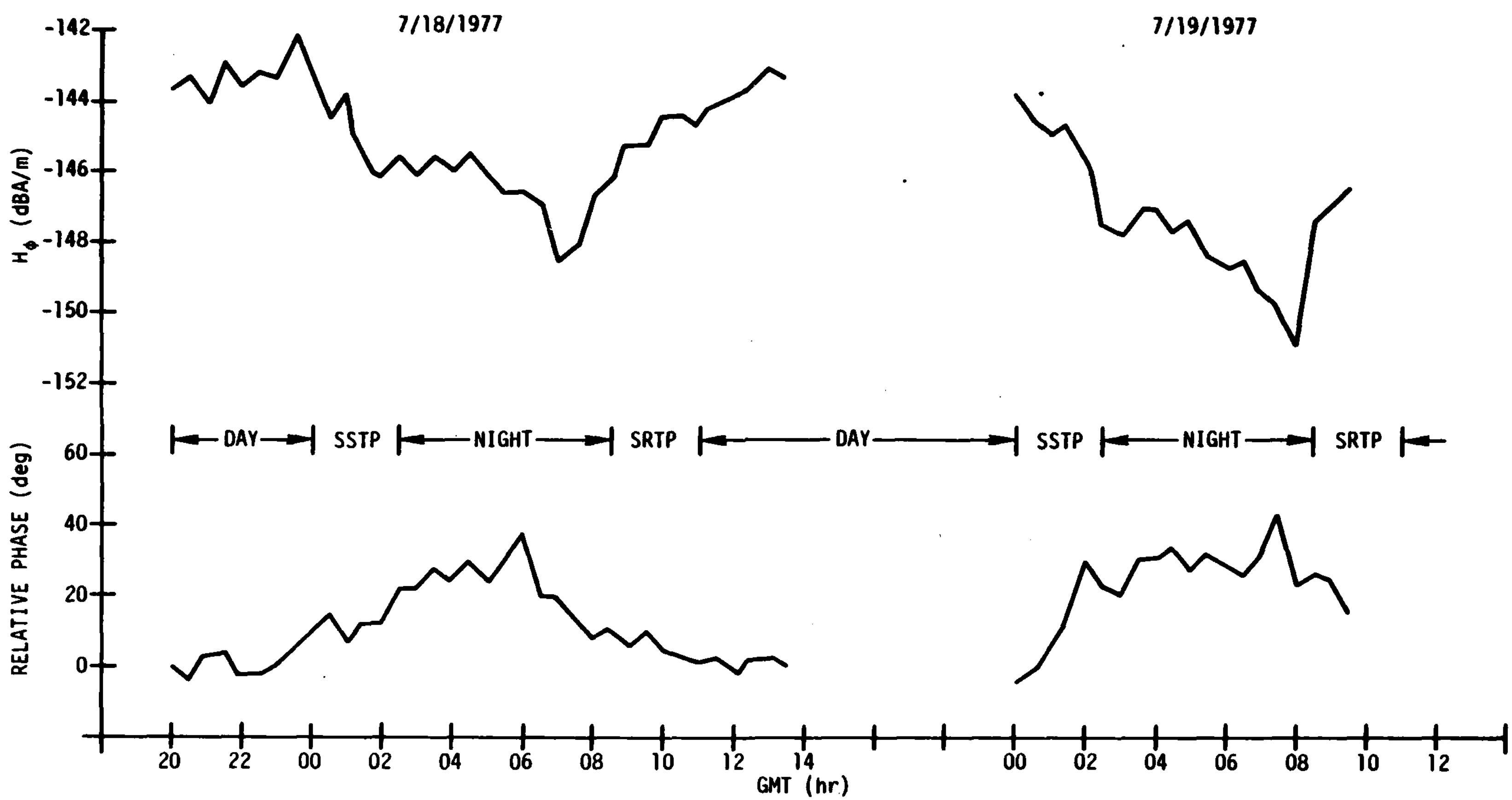

Figure 7. Connecticut Field Strength Versus GMT, 18 and 19 July 1977

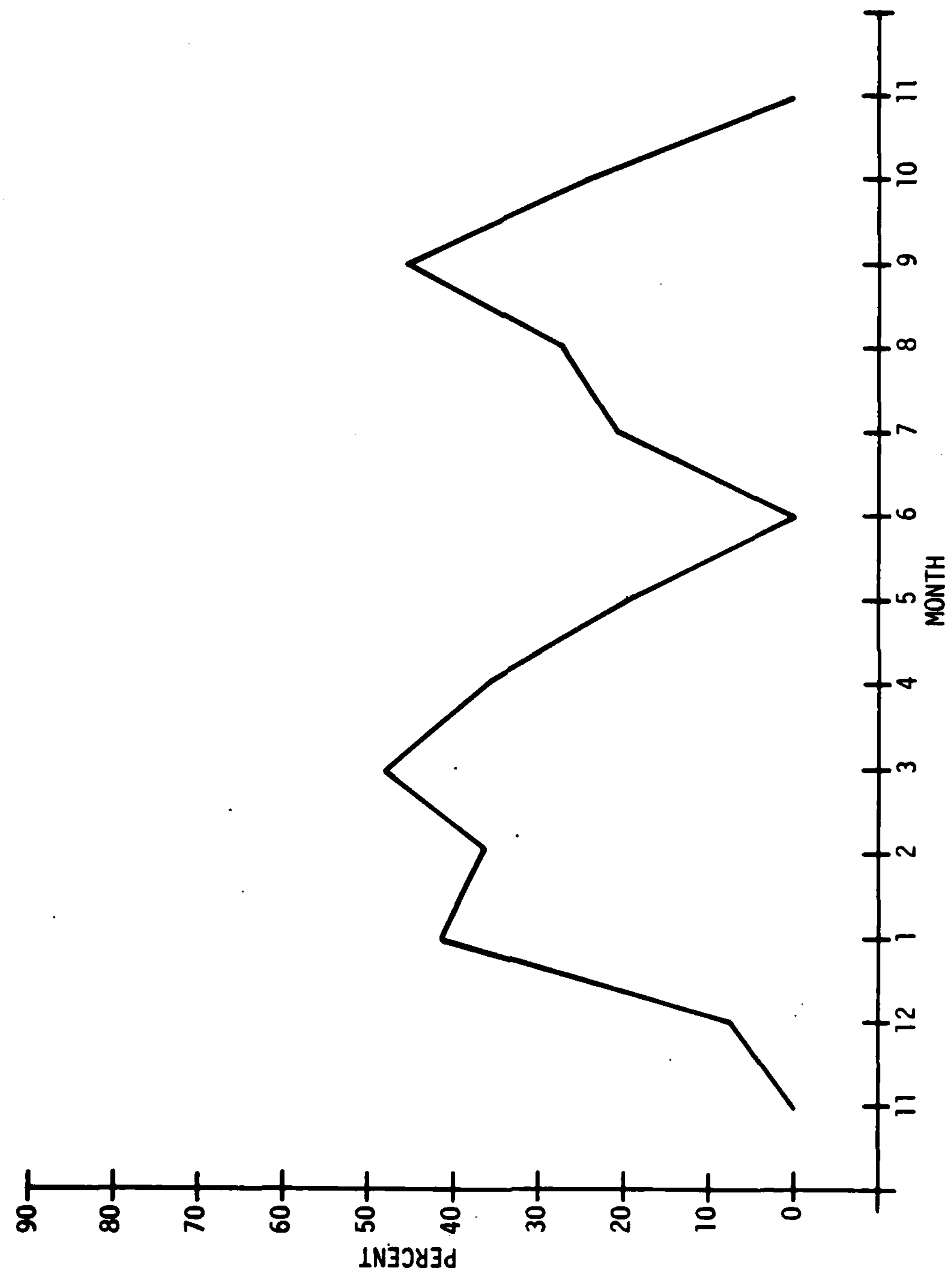

Figure 8. Percent of Measurement Days (August 1976 to July 1977) Where the Daily Amplitude Peak-to-Trough Variation Was ≥ 5 dB

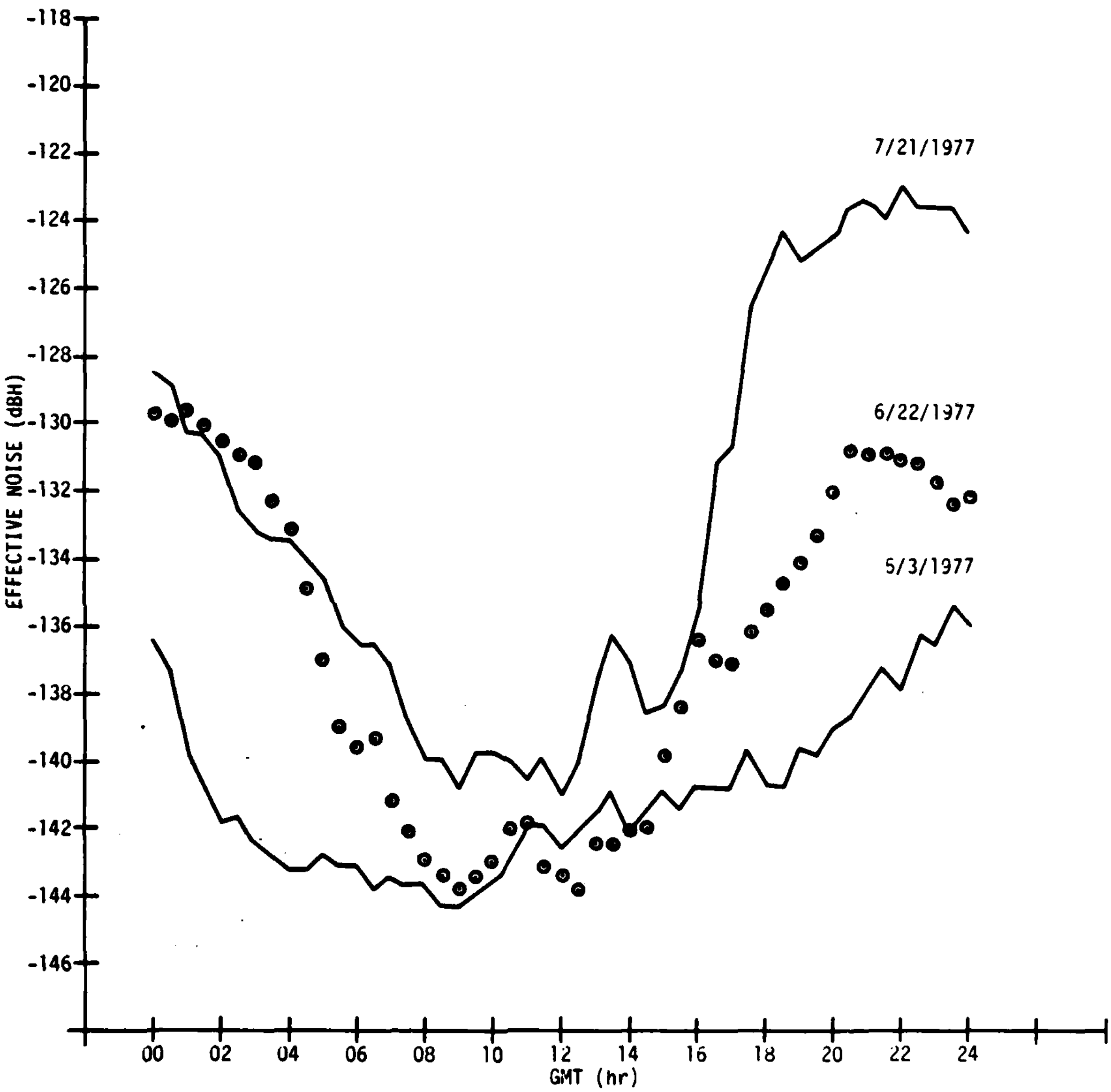

Figure 9. Connecticut Effective Noise Versus GMT
Plots for Three Selected Days

REFERENCES

1. P. R. Bannister, F. J. Williams, J. R. Katan, and R. F. Ingram, Results of ELF Farfield Measurements Made in Connecticut, June 1970 - May 1973, NUSC Technical Report 4617, Naval Underwater Systems Center, New London, CT, 17 October 1973.

2. P. R. Bannister and F. J. Williams, ELF Field Strength Measurements Made in Connecticut From September 1973 Through January 1974, NUSC Technical Report 4719, Naval Underwater Systems Center, New London, CT, 6 May 1974.

3. P. R. Bannister and F. J. Williams, ELF Field Strength Measurements Made in Connecticut During 1974, NUSC Technical Report 4927, Naval Underwater Systems Center, New London, CT, 1 October 1975.

4. P. R. Bannister, ELF Effective Noise Measurements Taken in Connecticut During 1976, NUSC Technical Report 5681, Naval Underwater Systems Center, New London, CT, 5 August 1977.

5. P. R. Bannister and F. J. Williams, ELF Field Strength Measurements Made in Connecticut During 1975, NUSC Technical Report 5695, Naval Underwater Systems Center, New London, CT, 15 August 1977.

6. P. R. Bannister, ELF Field Strength Measurements Made in Connecticut During 1976, NUSC Technical Report 5853, Naval Underwater Systems Center, New London, CT, 11 September 1978.

7. P. R. Bannister et al., Extremely Low Frequency (ELF) Propagation, NUSC Scientific and Engineering Studies, Naval Underwater Systems Center, New London, CT, February 1980, 550 pp.

8. P. R. Bannister, ELF PVS Field Strength Measurements, January 1977, NUSC Technical Report 6879, Naval Underwater Systems Center, New London, CT, 21 March 1983.

9. P. R. Bannister, ELF PVS Field Strength Measurements, March 1977, NUSC Technical Report 6769, Naval Underwater Systems Center, New London, CT, 3 February 1983.

10. P. R. Bannister, ELF PVS Field Strength Measurements, April 1977, NUSC Technical Report 6771, Naval Underwater Systems Center, New London, CT, 3 February 1983.

11. P. R. Bannister, ELF PVS Field Strength Measurements, October 1977, NUSC Technical Report 6773, Naval Underwater Systems Center, New London, CT, 3 February 1983.

12. P. R. Bannister, ELF PVS Field Strength Measurements, January/February 1978, NUSC Technical Report 6775, Naval Underwater Systems Center, New London, CT, 3 February 1983.

13. J. E. Evans and A. S. Griffiths, "Design of a Sanguine Noise Processor Based Upon World-Wide Extremely Low Frequency (ELF) Recordings," IEEE Transactions on Communications, vol. COM-22, no. 4, 1974, pp. 528-539.

14. P. R. Bannister, "Overview of ELF Propagation," NATO/AGARD Meeting of the Electromagnetic Wave Propagation Panel (Medium, Long, and Very Long Wave Propagation), 21-25 September 1981, Brussels, Belgium, Rep. 10, pp. 10.1-10.13, available through NTIS, Springfield, VA.

15. P. R. Bannister, "Localized ELF Nocturnal Propagation Anomalies," Radio Science, vol. 17, no. 3, 1982, pp. 627-634.

Appendix A

CONNECTICUT DAILY DATA, MAY 1977

Daily plots of Connecticut signal-strength, effective-noise, and SNR values versus GMT for May 1977 are given in this appendix as figures A-1 through A-28.

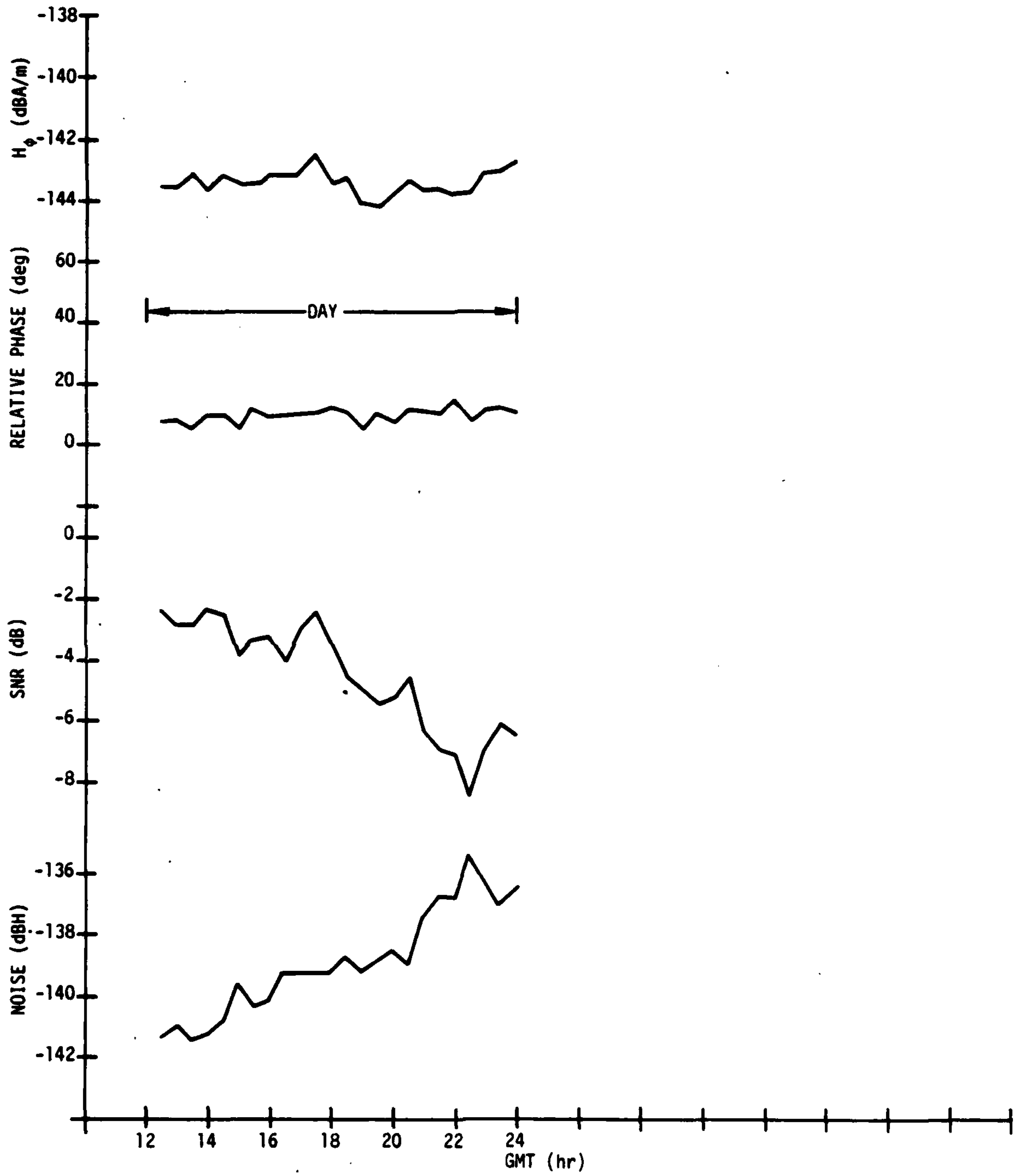

Figure A-1. Connecticut Data Versus GMT
(ψ = 291 deg), 2 May 1977

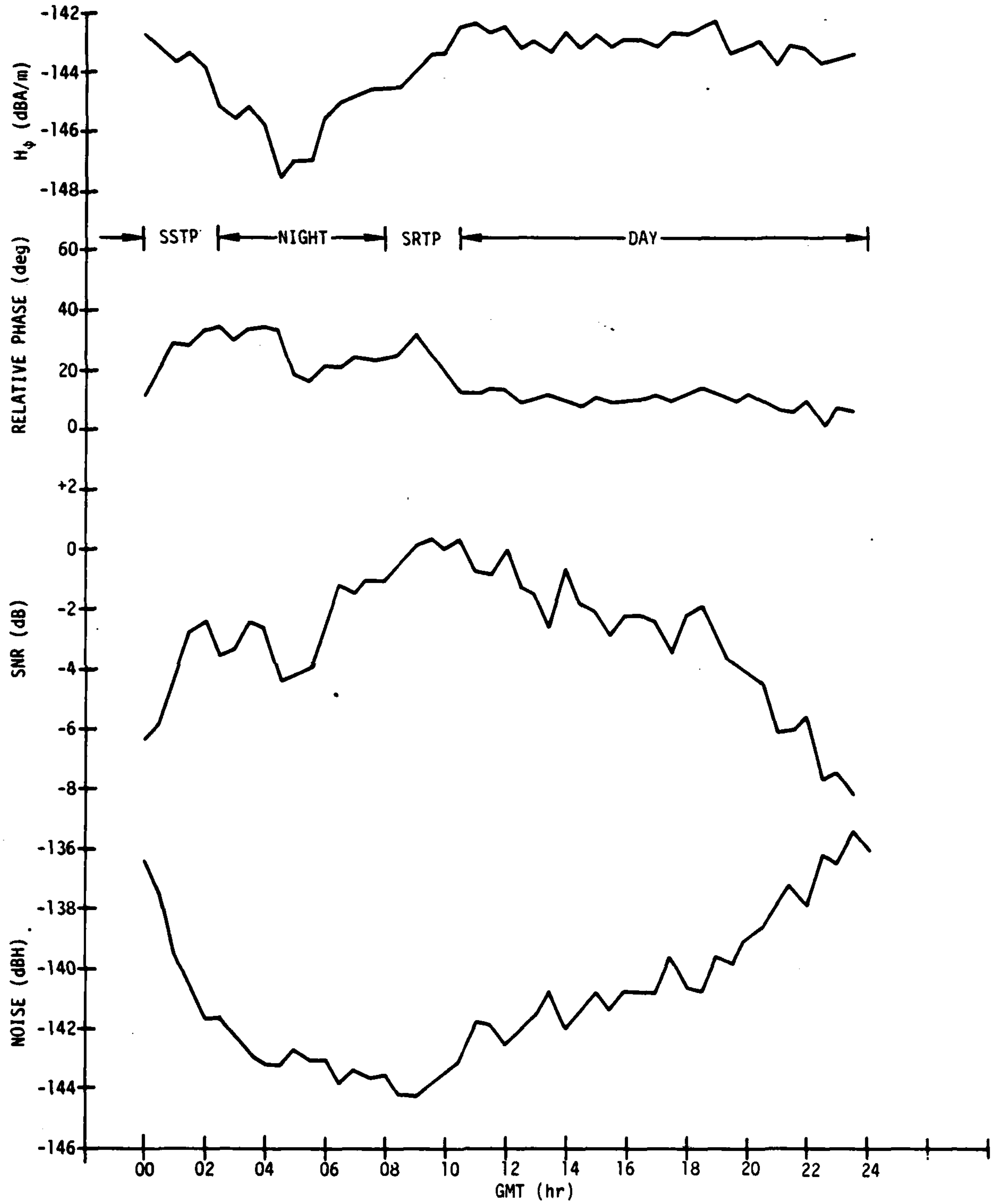

Figure A-2. Connecticut Data Versus GMT
(ψ = 291 deg), 3 May 1977

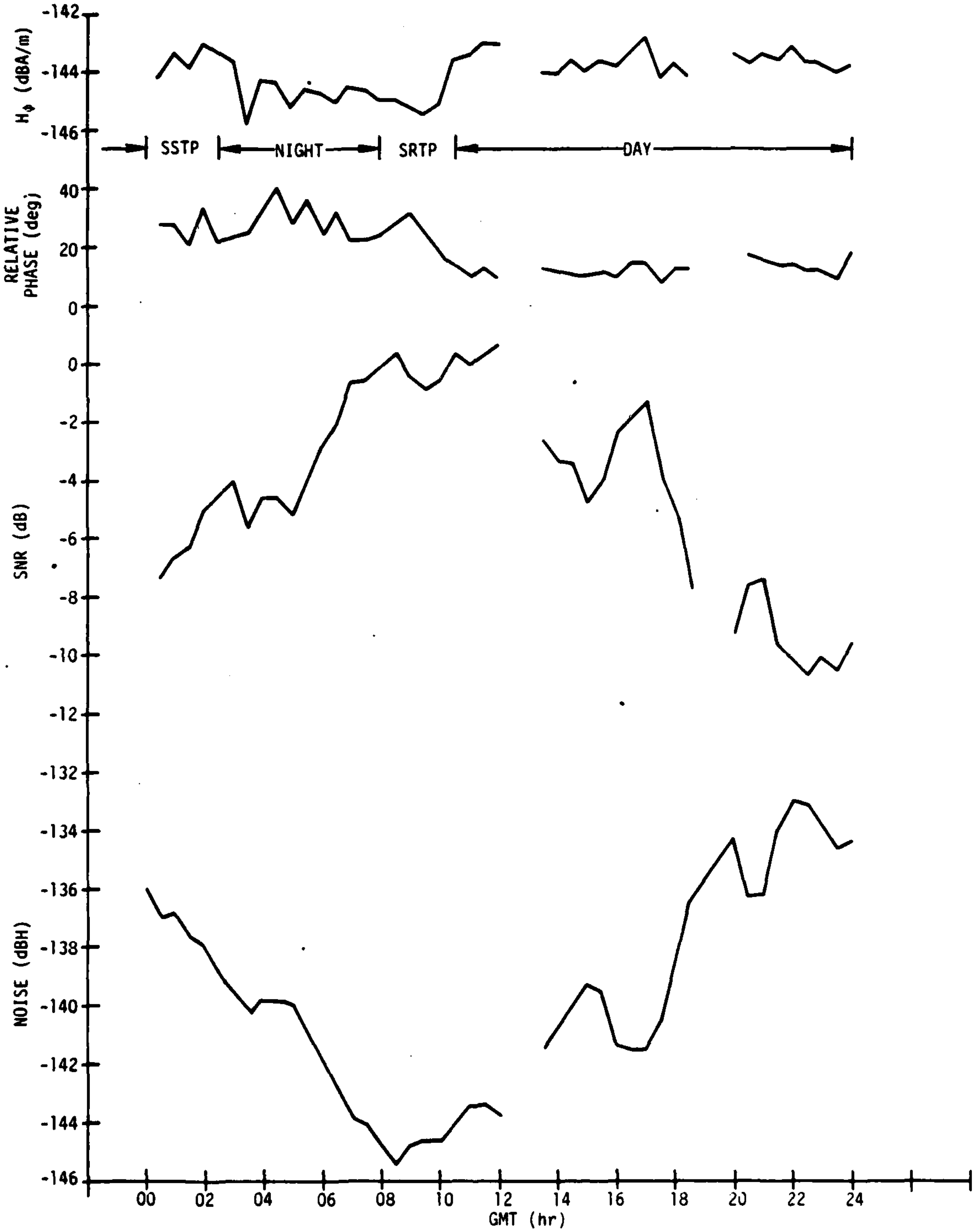

Figure A-3. Connecticut Data Versus GMT
(ψ = 291 deg), 4 May 1977

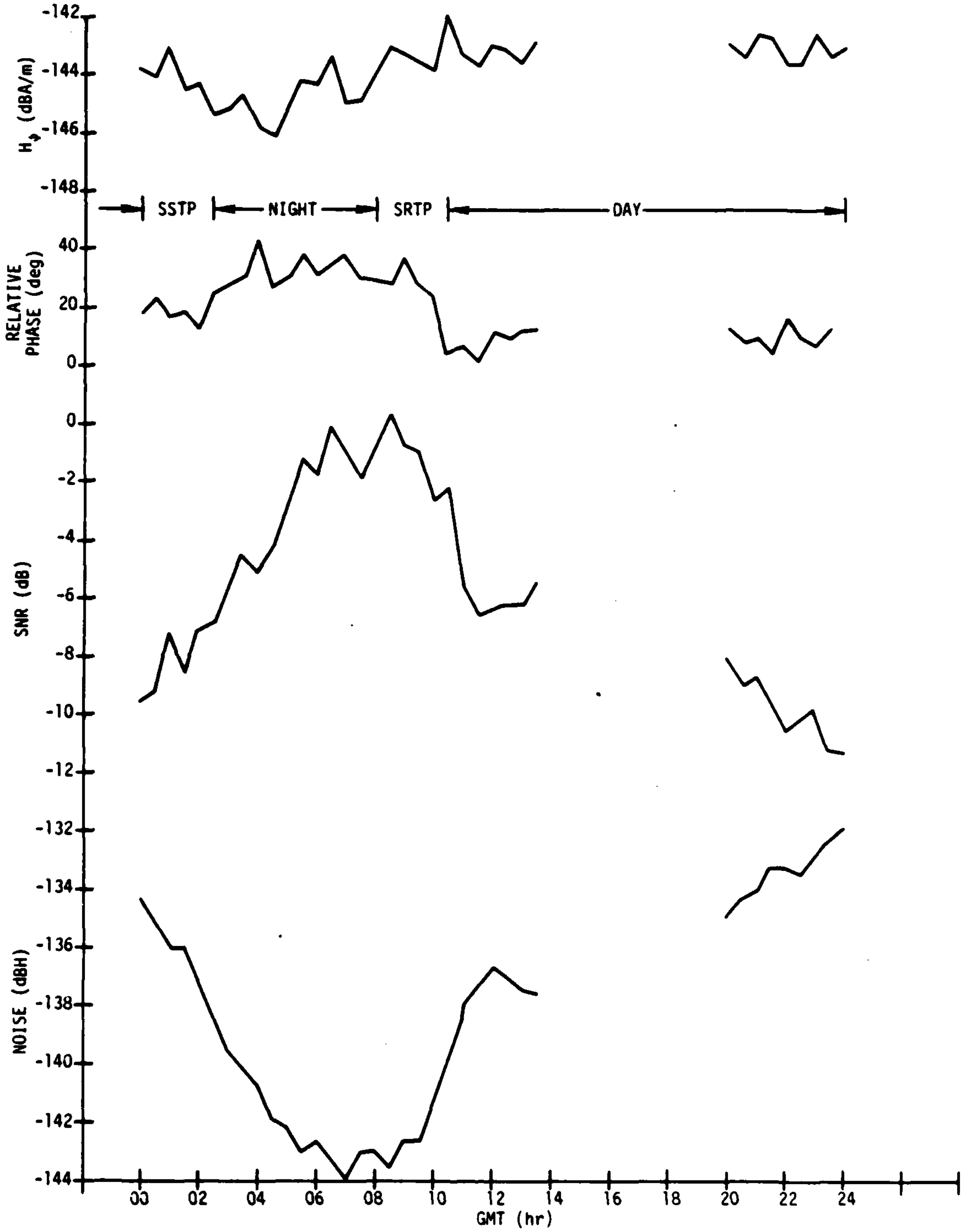

Figure A-4. Connecticut Data Versus GMT (ψ = 291 deg), 5 May 1977

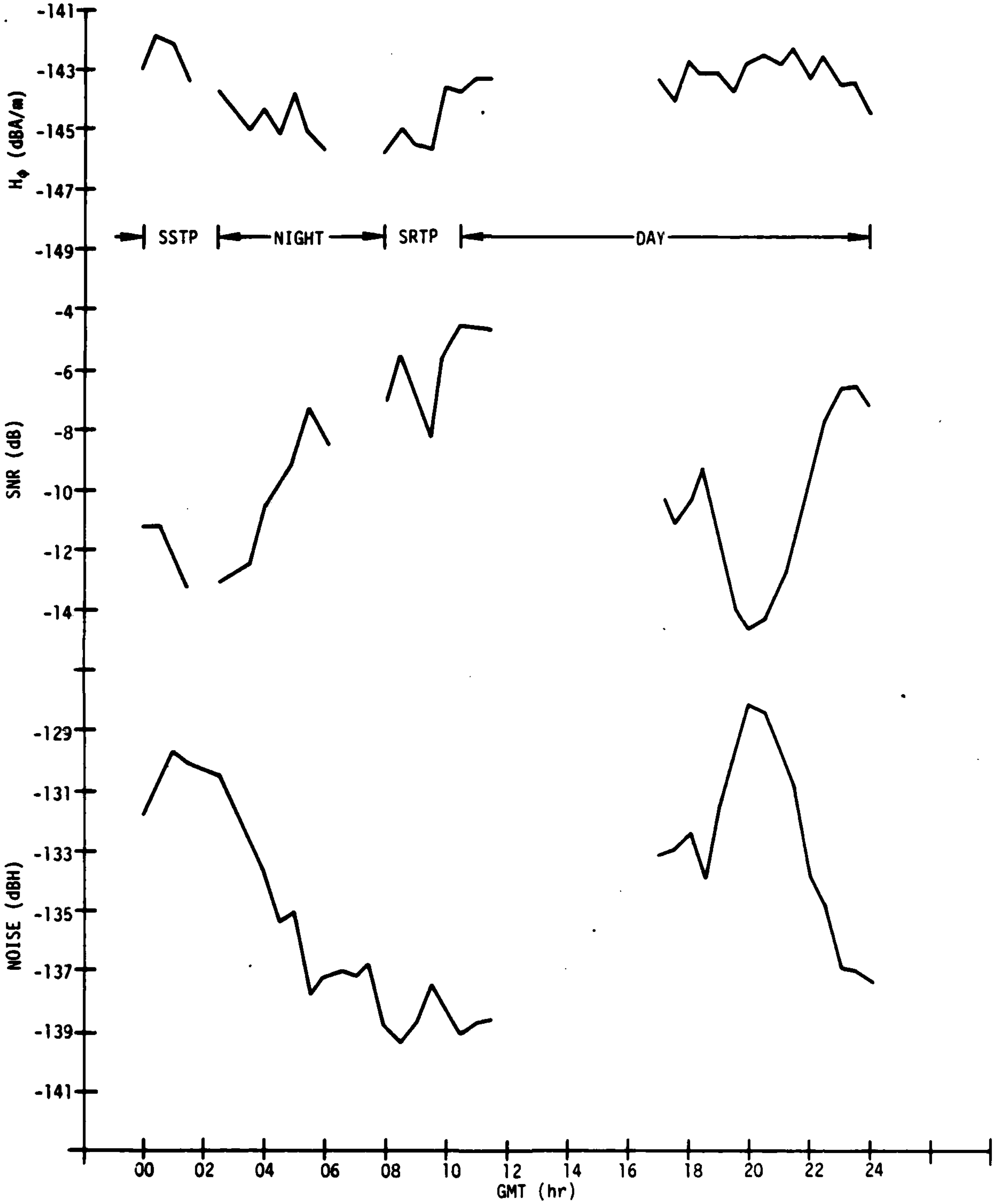

Figure A-5. Connecticut Data Versus GMT
(ψ = 291 deg), 6 May 1977

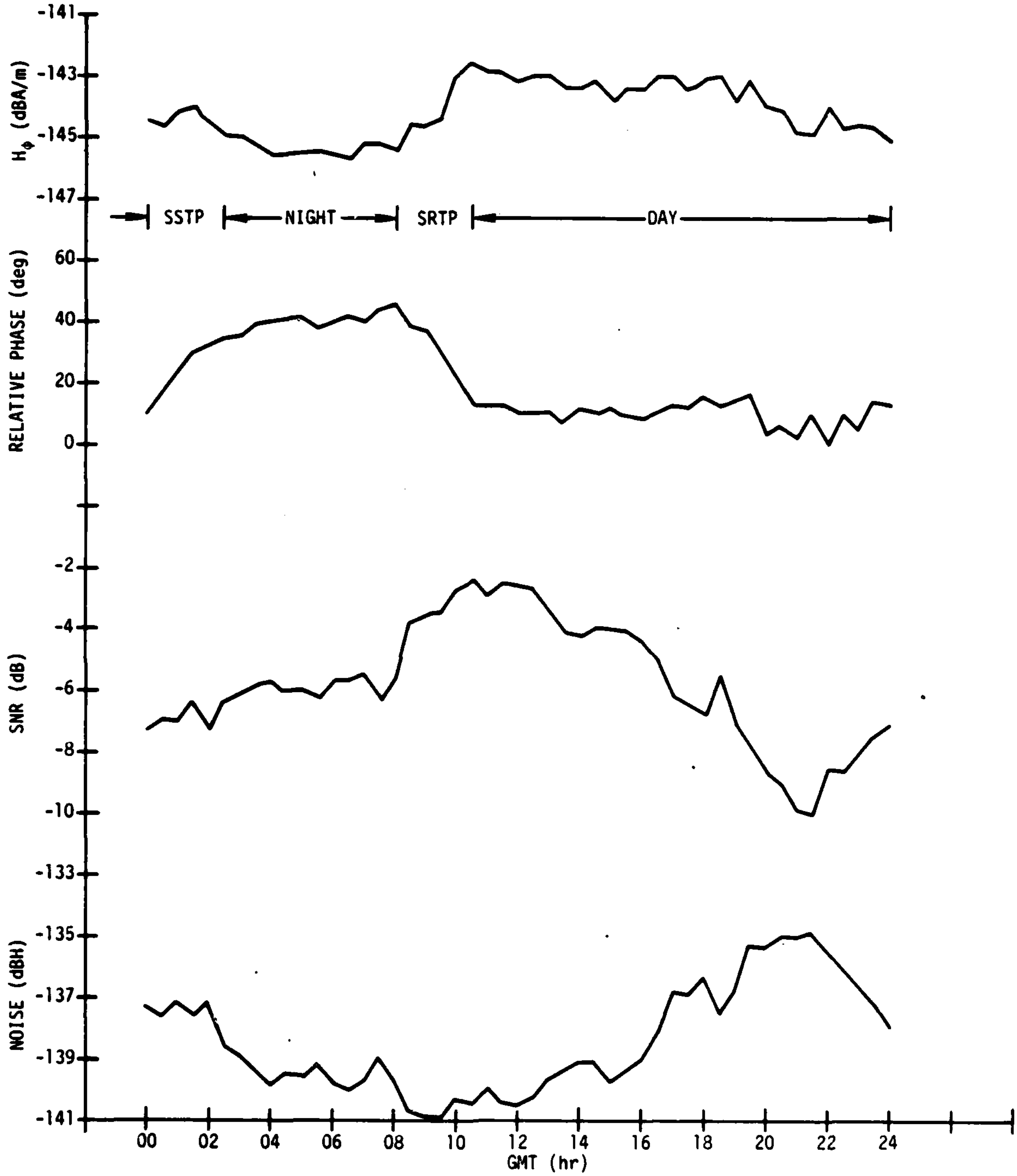

Figure A-6. Connecticut Data Versus GMT
(ψ = 291 deg), 7 May 1977

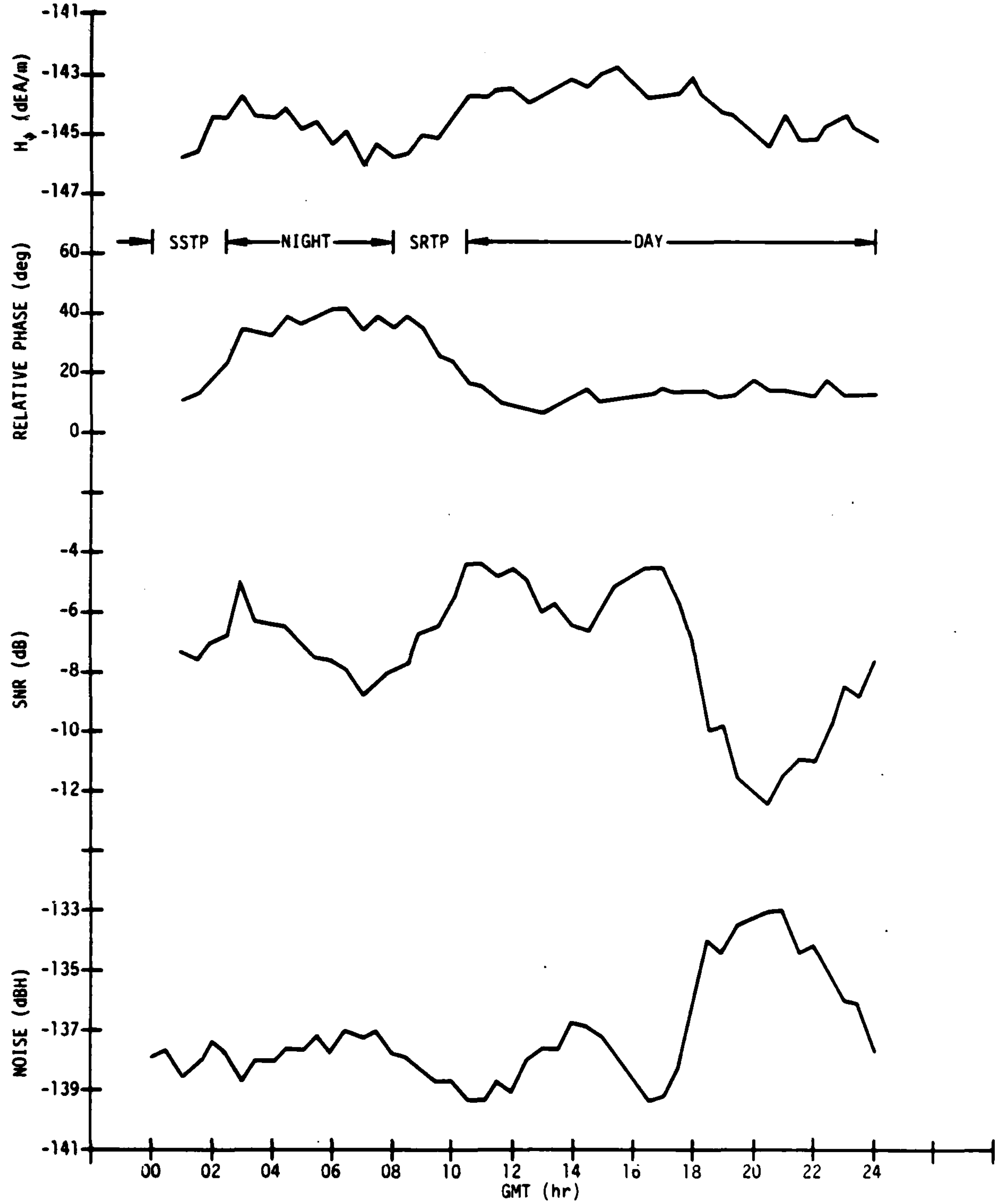

Figure A-7. Connecticut Data Versus GMT
(ψ = 291 deg), 8 May 1977

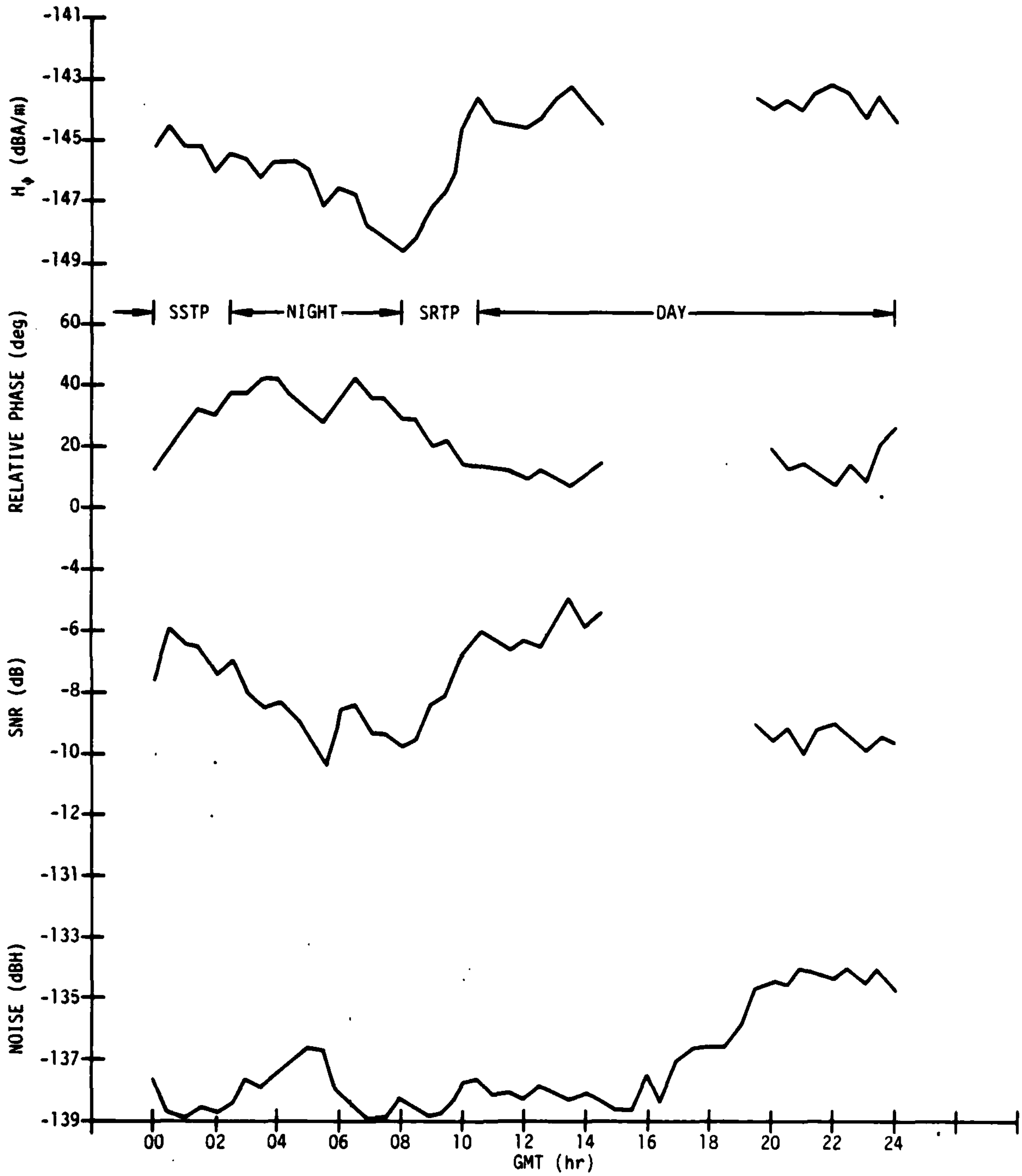

Figure A-8 Connecticut Data Versus GMT
(ψ = 291 deg), 9 May 1977

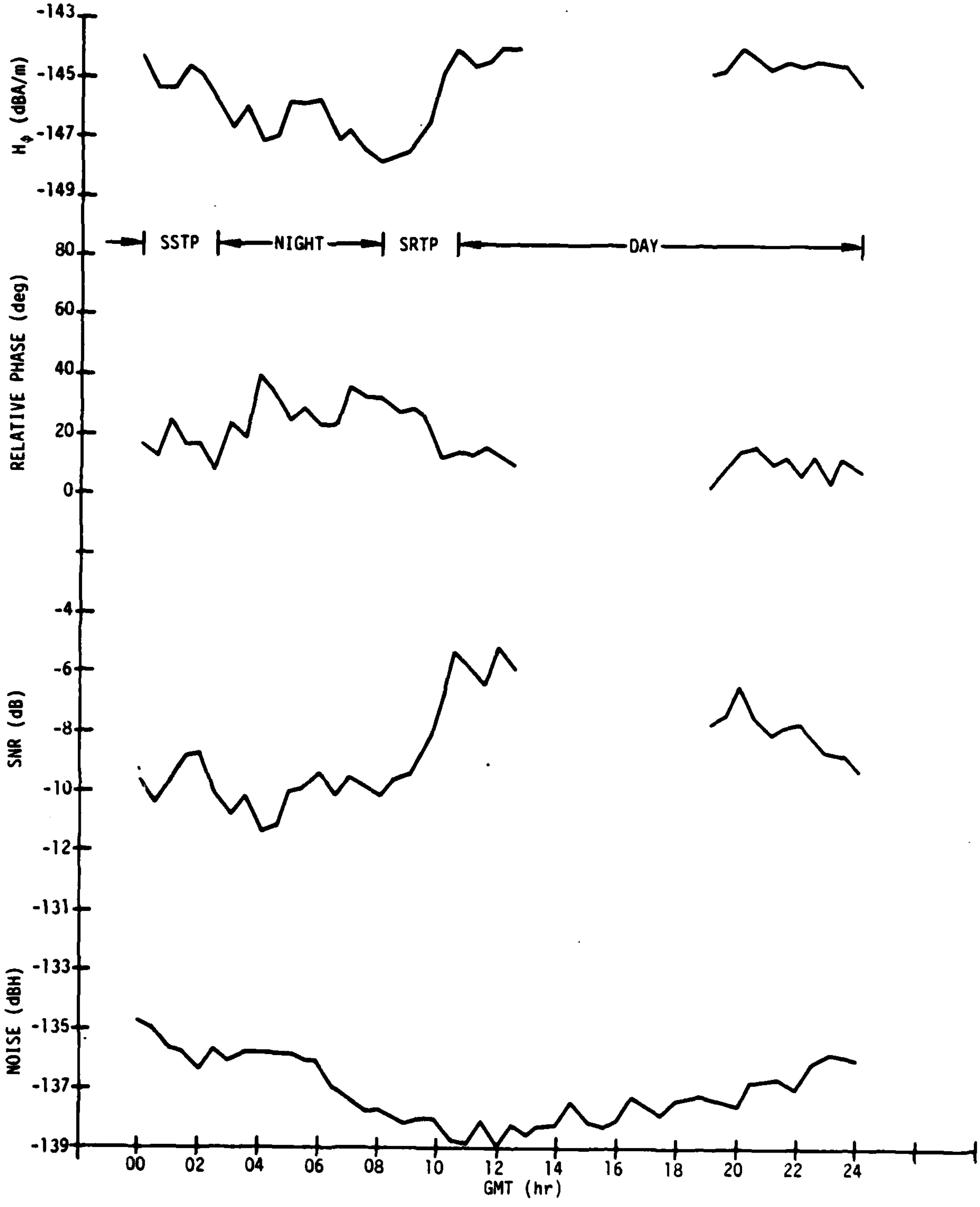

Figure A-9. Connecticut Data Versus GMT
(ψ = 291 deg), 10 May 1977

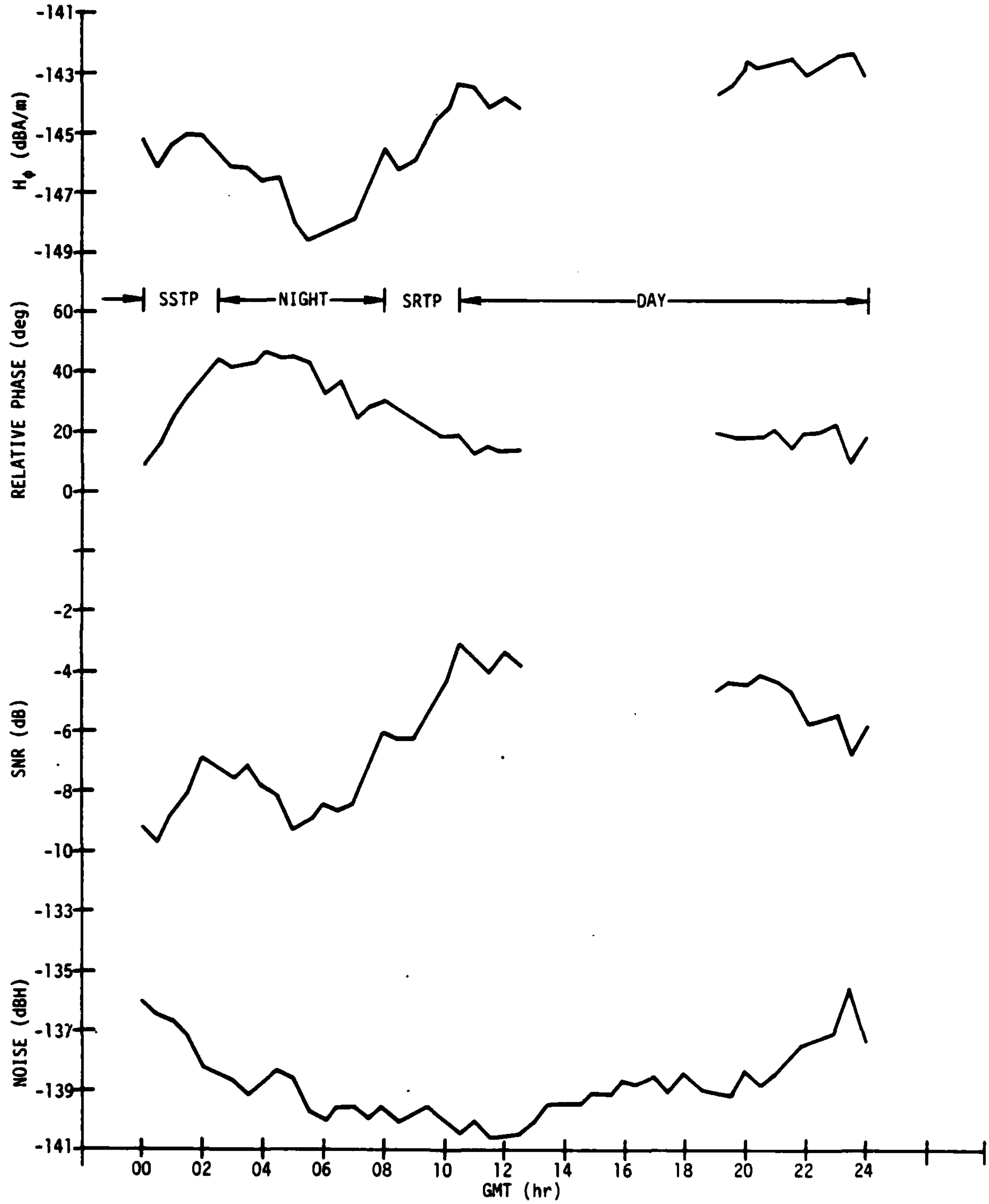

Figure A-10. Connecticut Data Versus GMT
(ψ = 291 deg), 11 May 1977

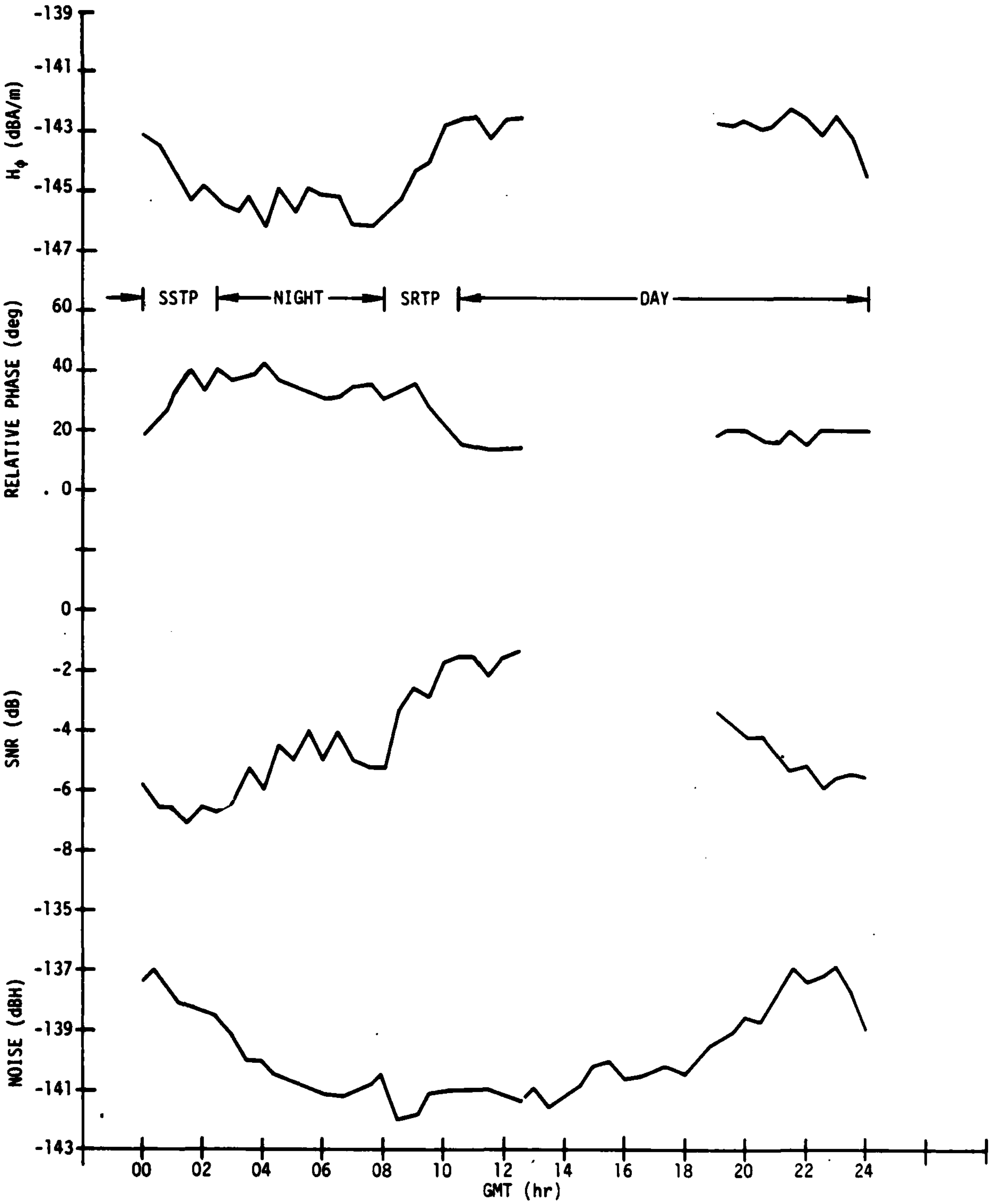

Figure A-11. Connecticut Data Versus GMT
(ψ = 291 deg), 12 May 1977

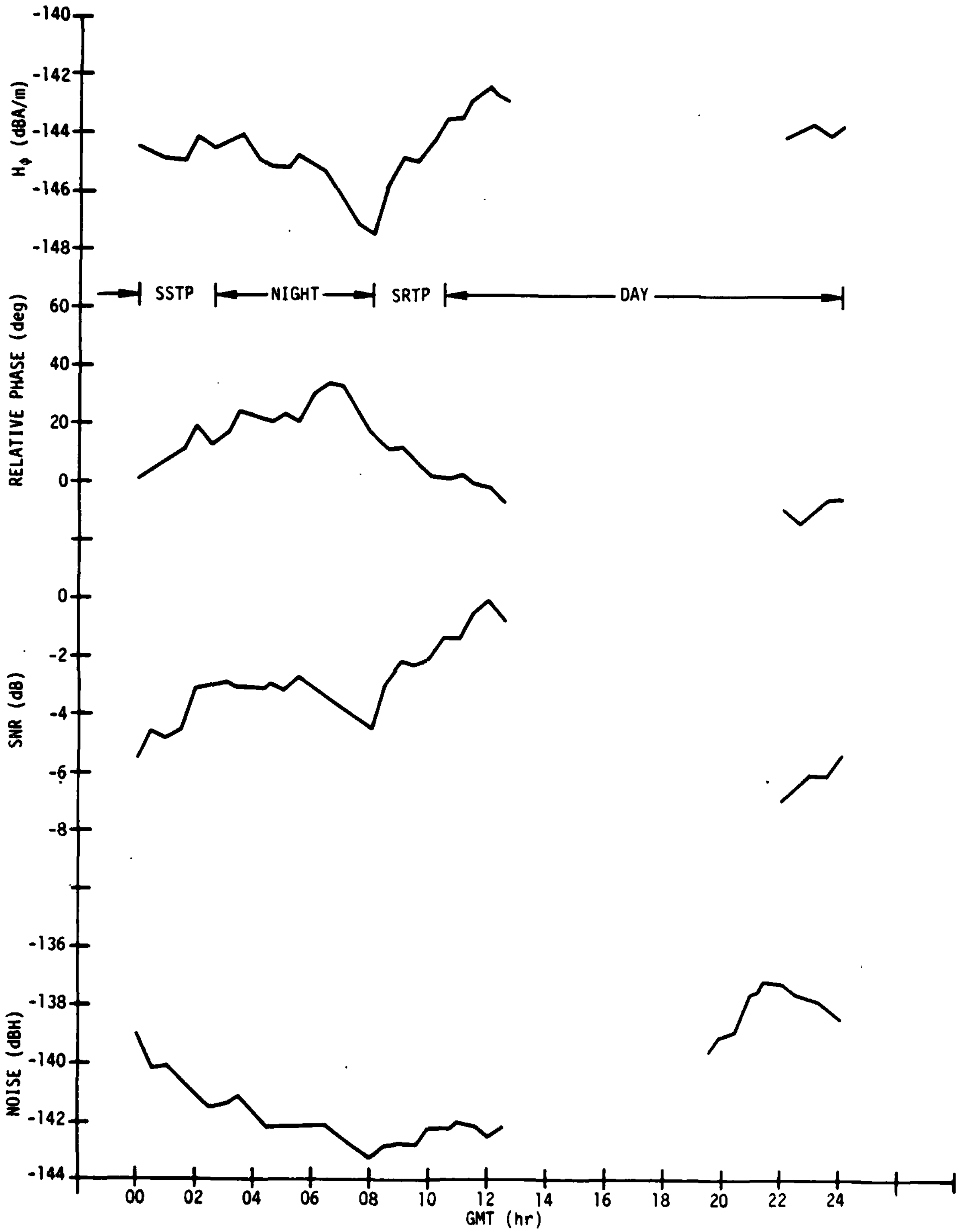

Figure A-12. Connecticut Data Versus GMT
(ψ = 291 deg), 13 May 1977

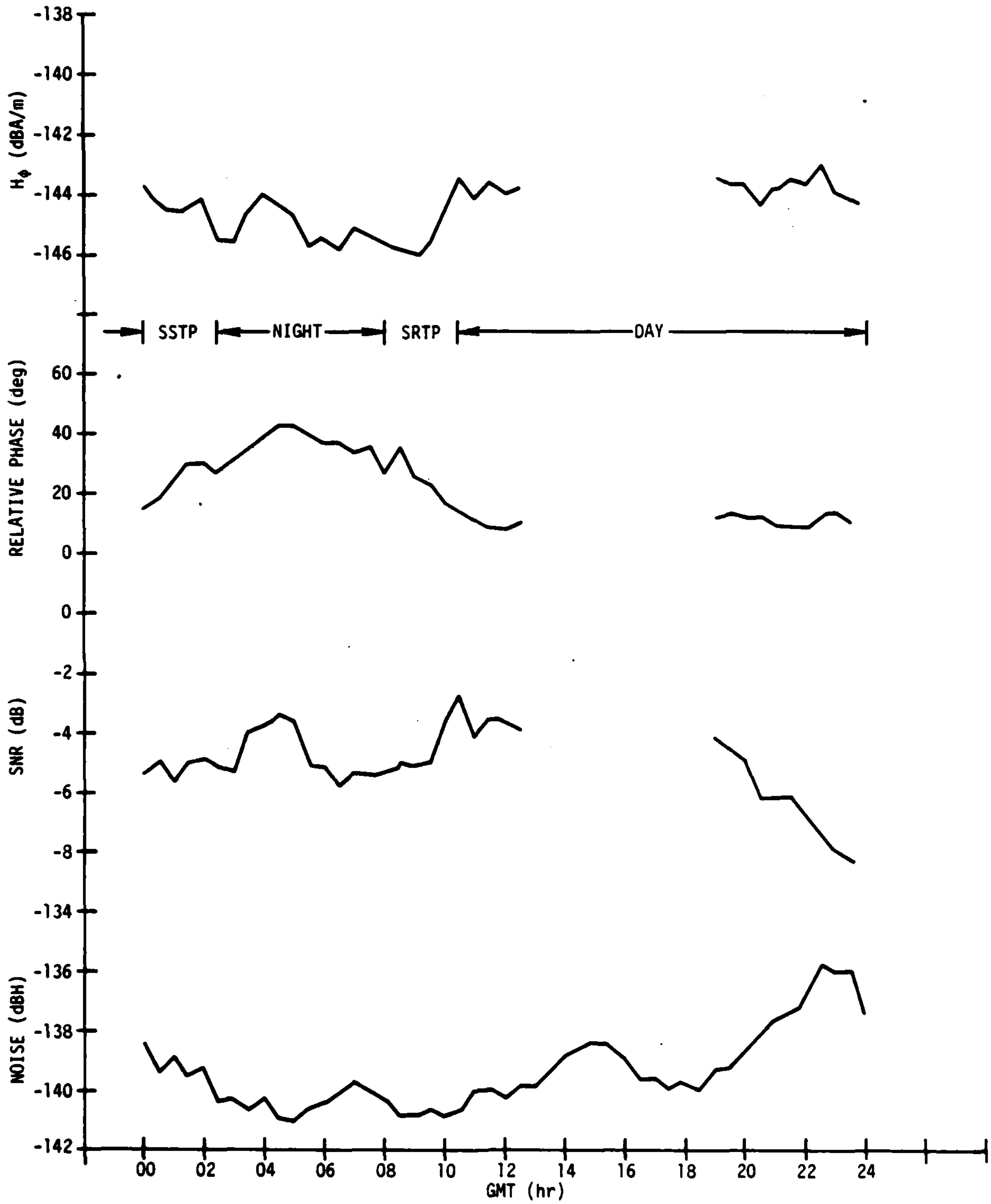

Figure A-13. Connecticut Data Versus GMT
(ψ = 291 deg), 14 May 1977

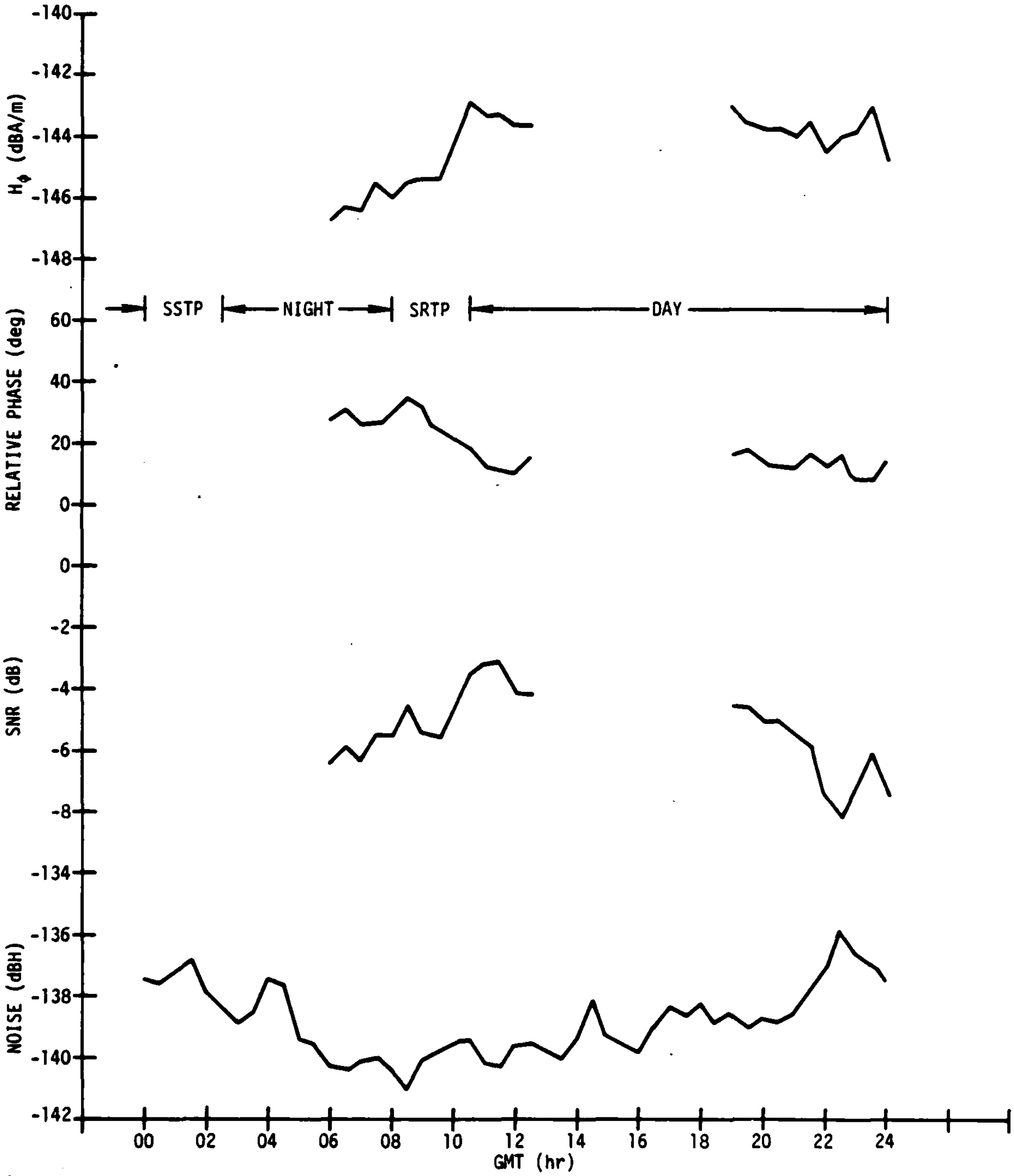

Figure A-14. Connecticut Data Versus GMT
(ψ = 291 deg), 15 May 1977

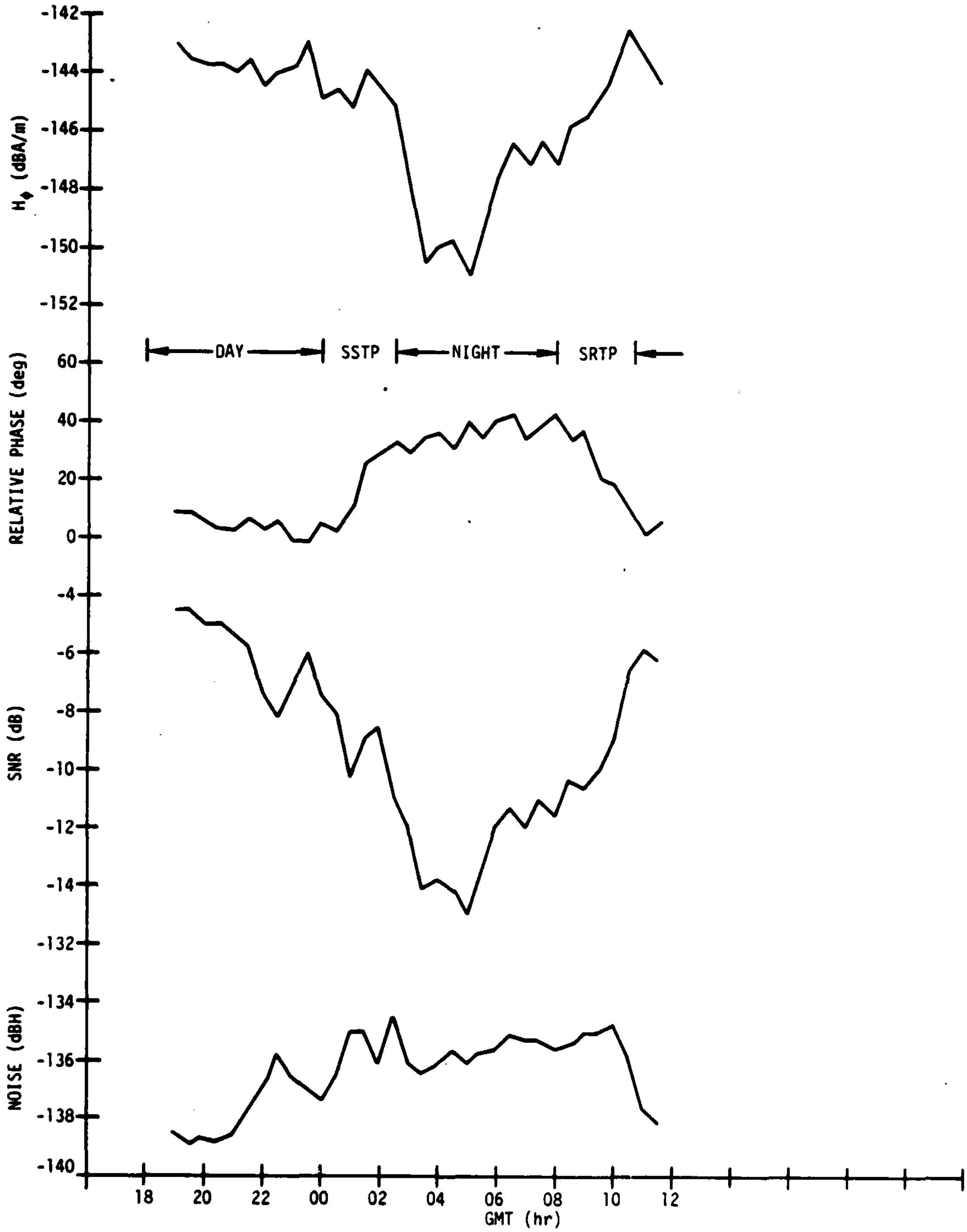

Figure A-15. Connecticut Data Versus GMT
(ψ = 291 deg), 16 May 1977

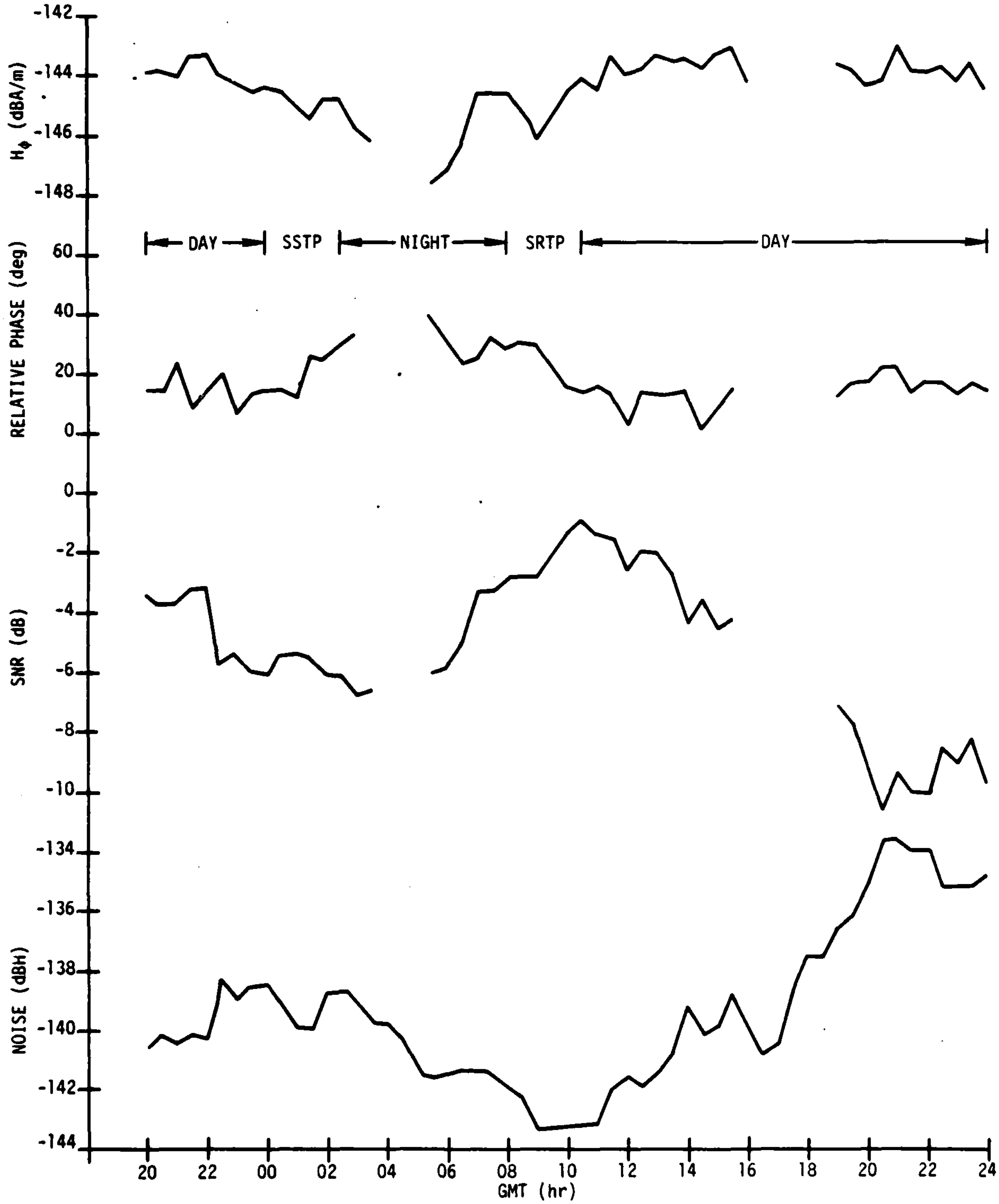

Figure A-16. Connecticut Data Versus GMT
(ψ = 291 deg), 18 May 1977

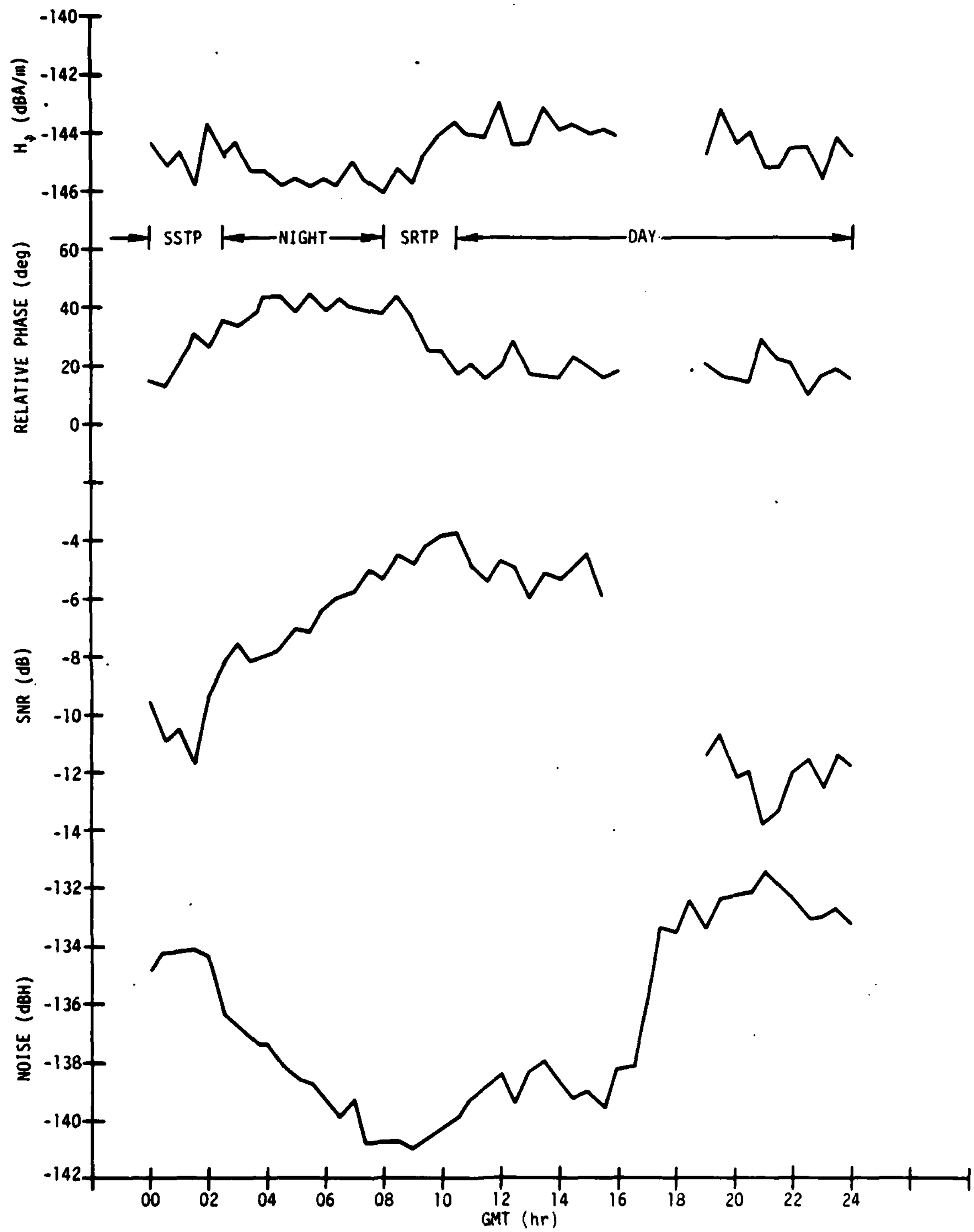

Figure A-17. Connecticut Data Versus GMT
(ψ = 291 deg), 19 May 1977

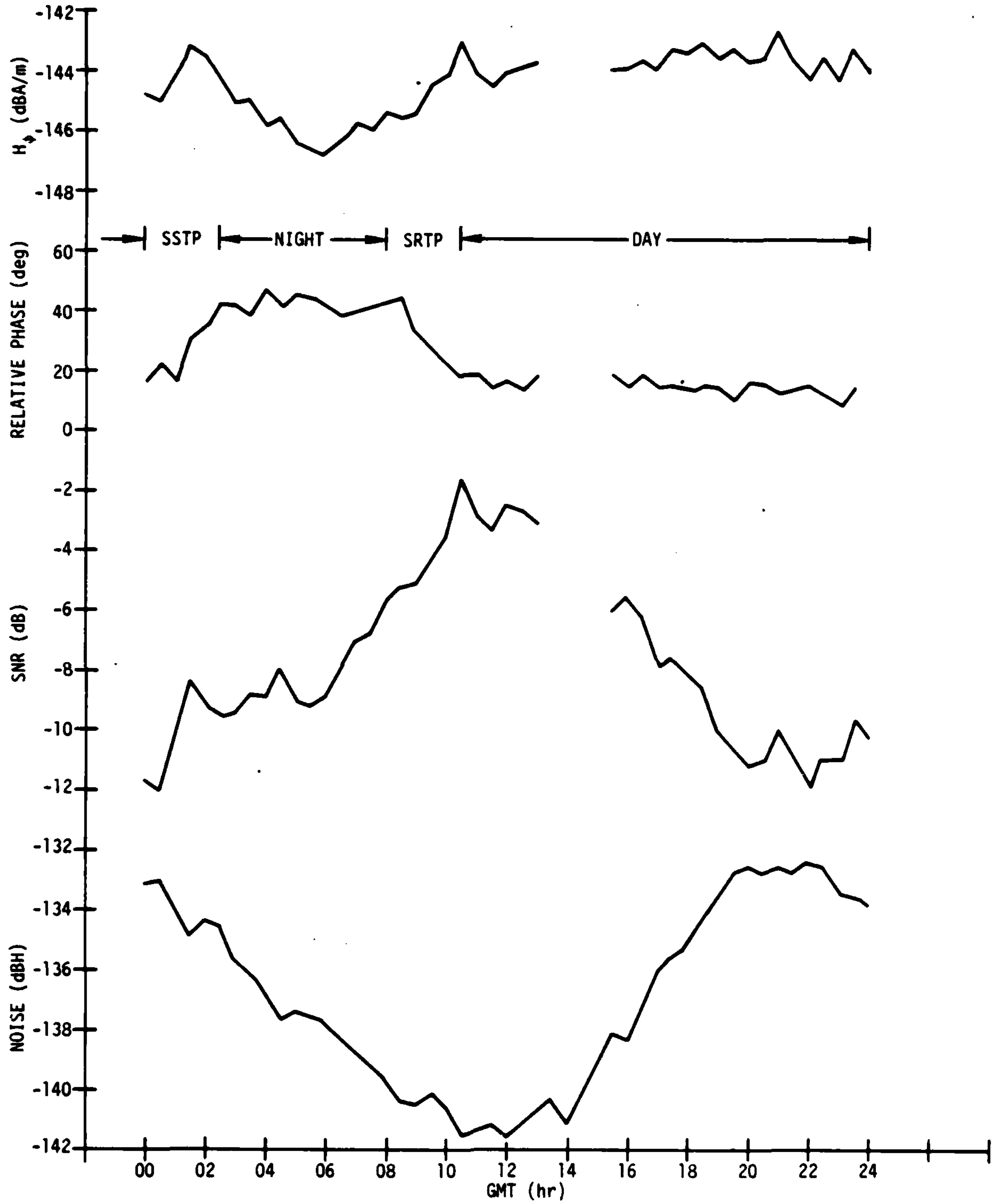

Figure A-18. Connecticut Data Versus GMT
(ψ = 291 deg), 20 May 1977

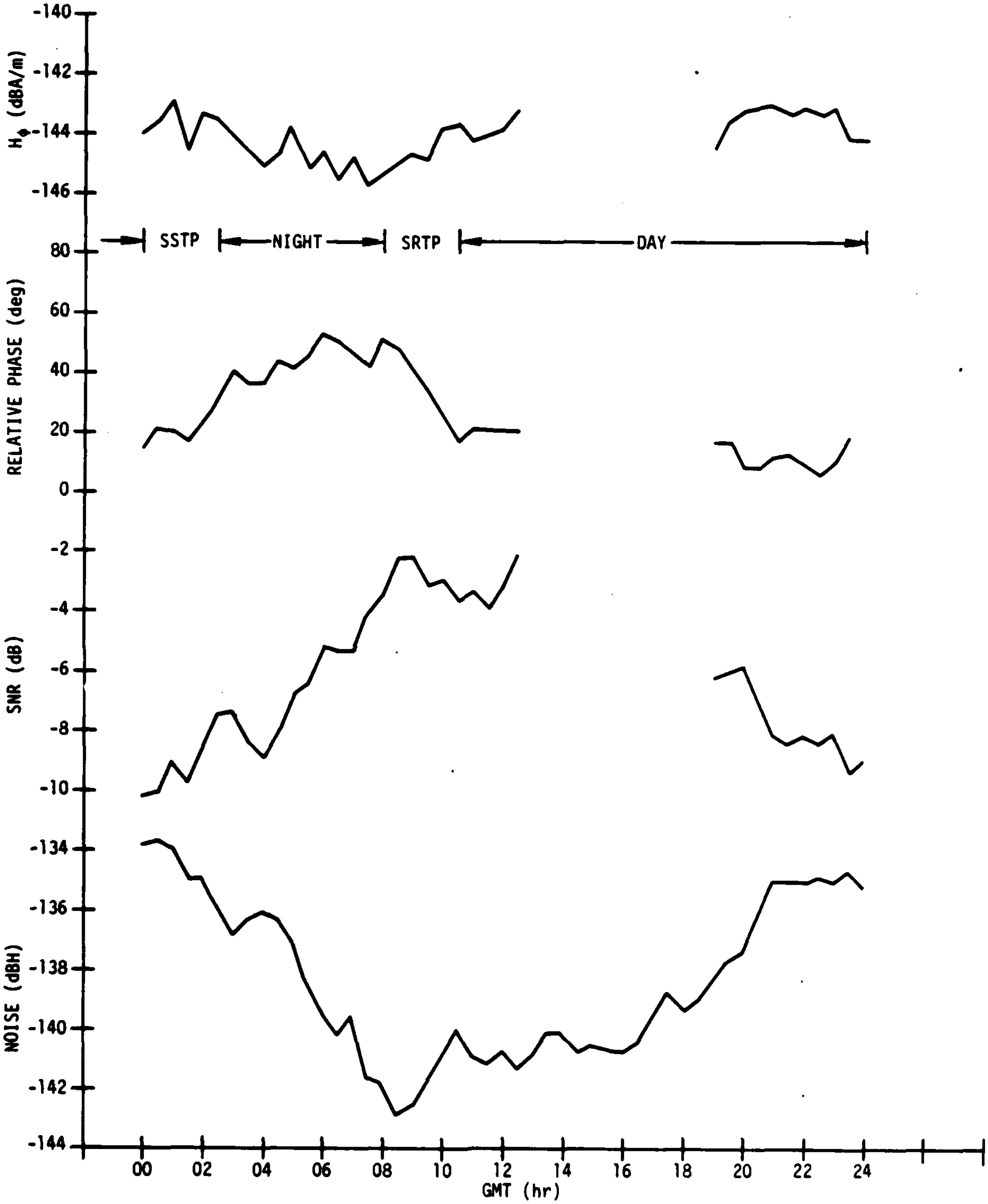

Figure A-19. Connecticut Data Versus GMT
(ψ = 291 deg), 21 May 1977

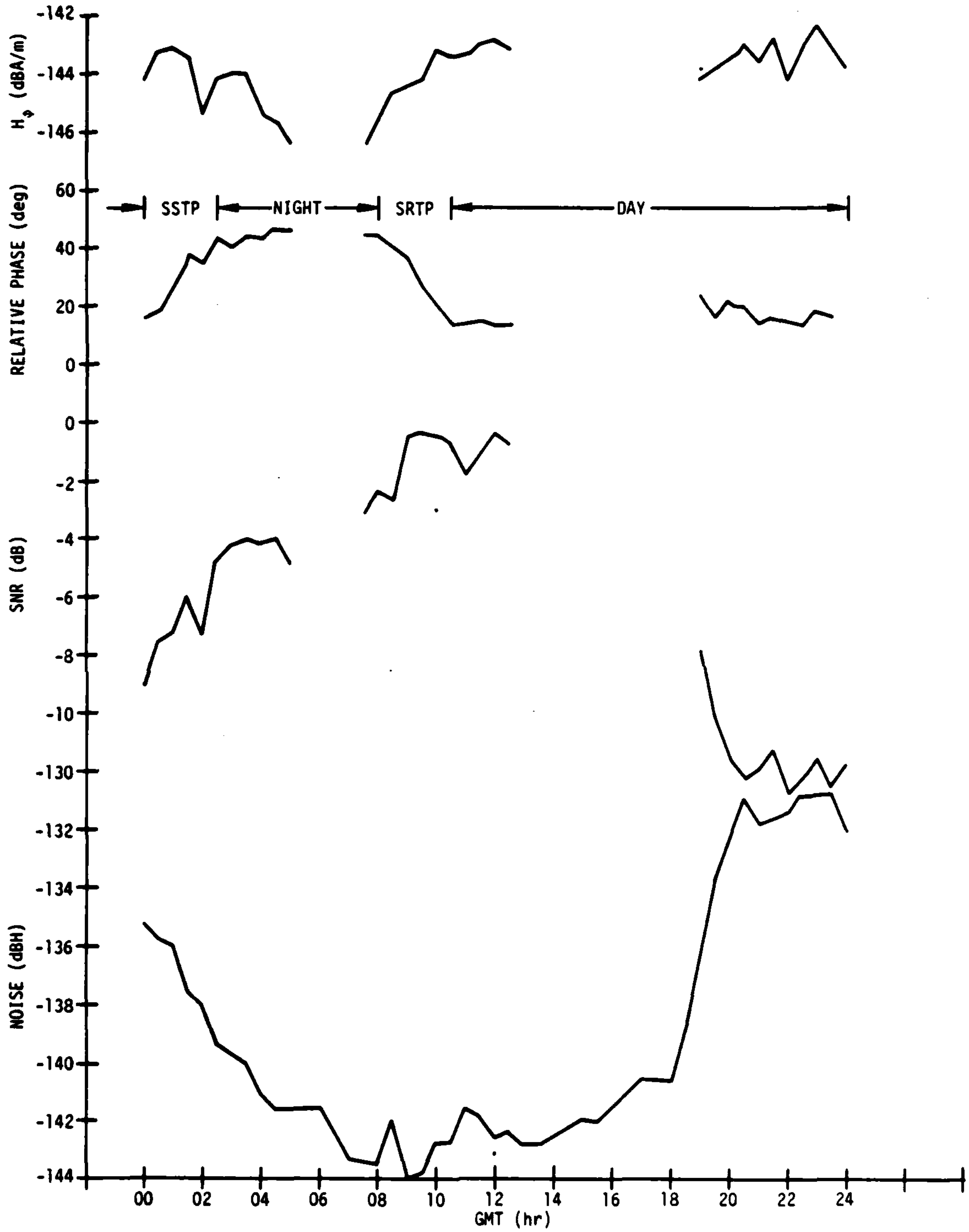

Figure A-20. Connecticut Data Versus GMT
(ψ = 291 deg), 22 May 1977

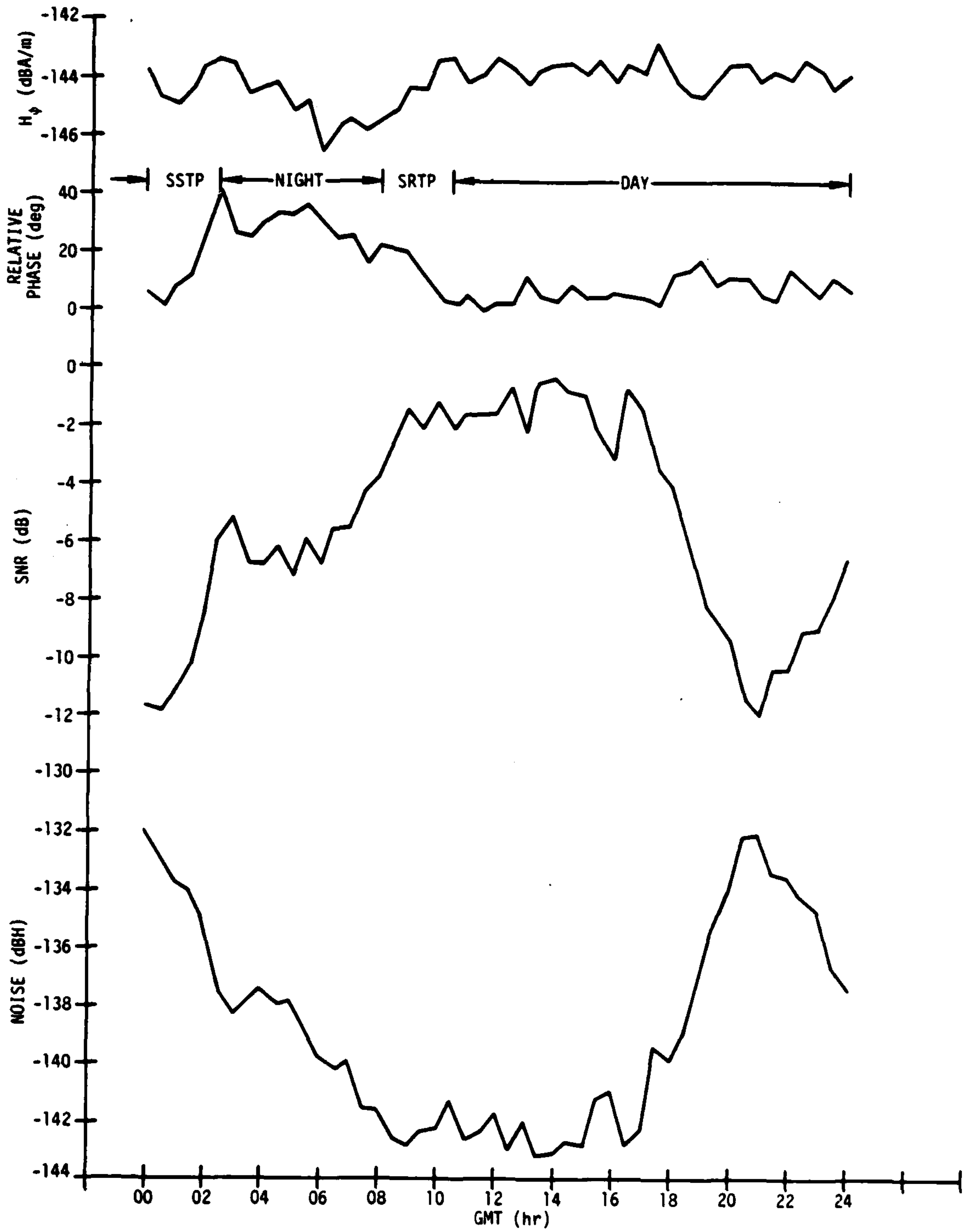

Figure A-21. Connecticut Data Versus GMT
(ψ = 291 deg), 23 May 1977

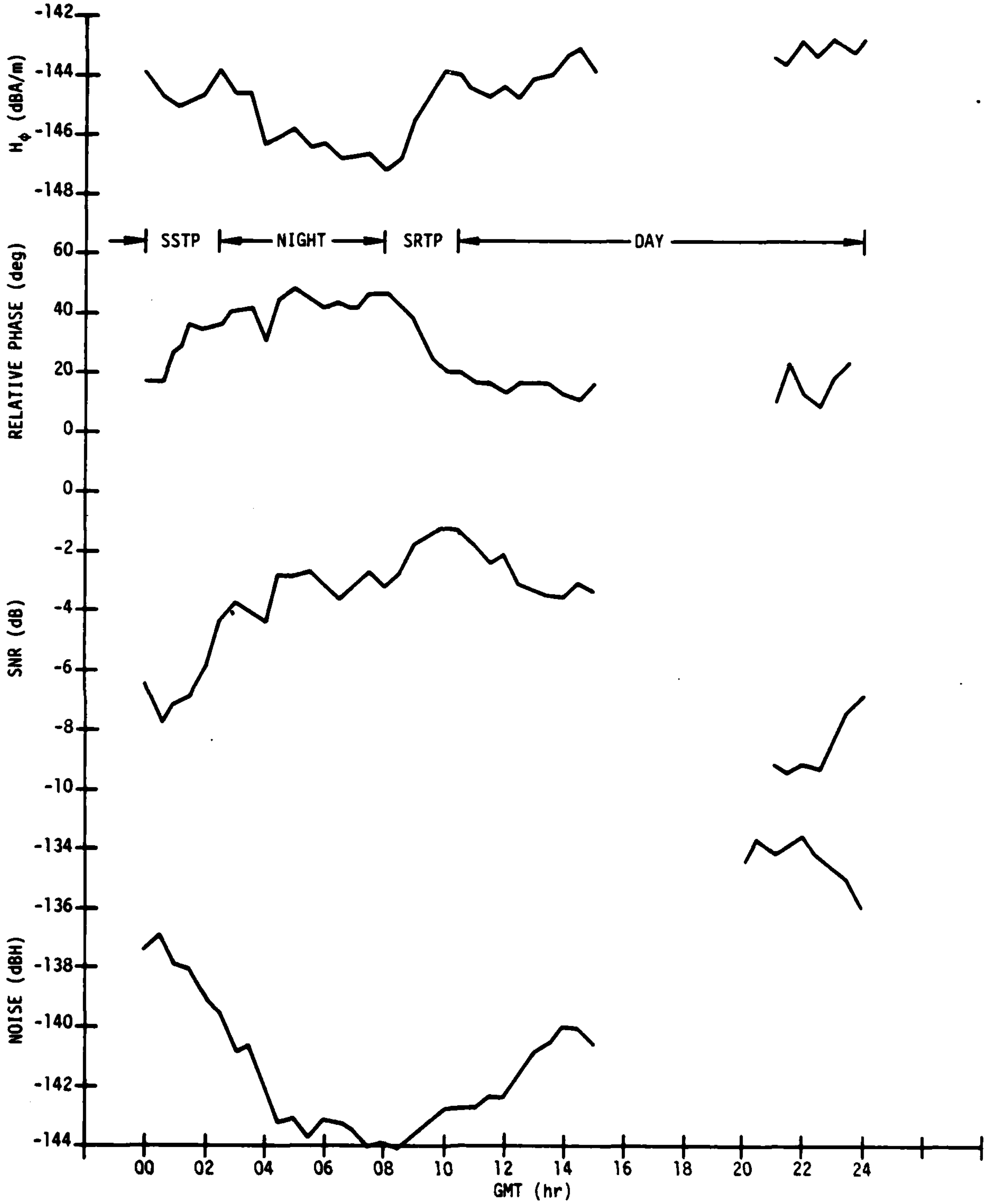

Figure A-22. Connecticut Data Versus GMT
(ψ = 291 deg), 24 May 1977

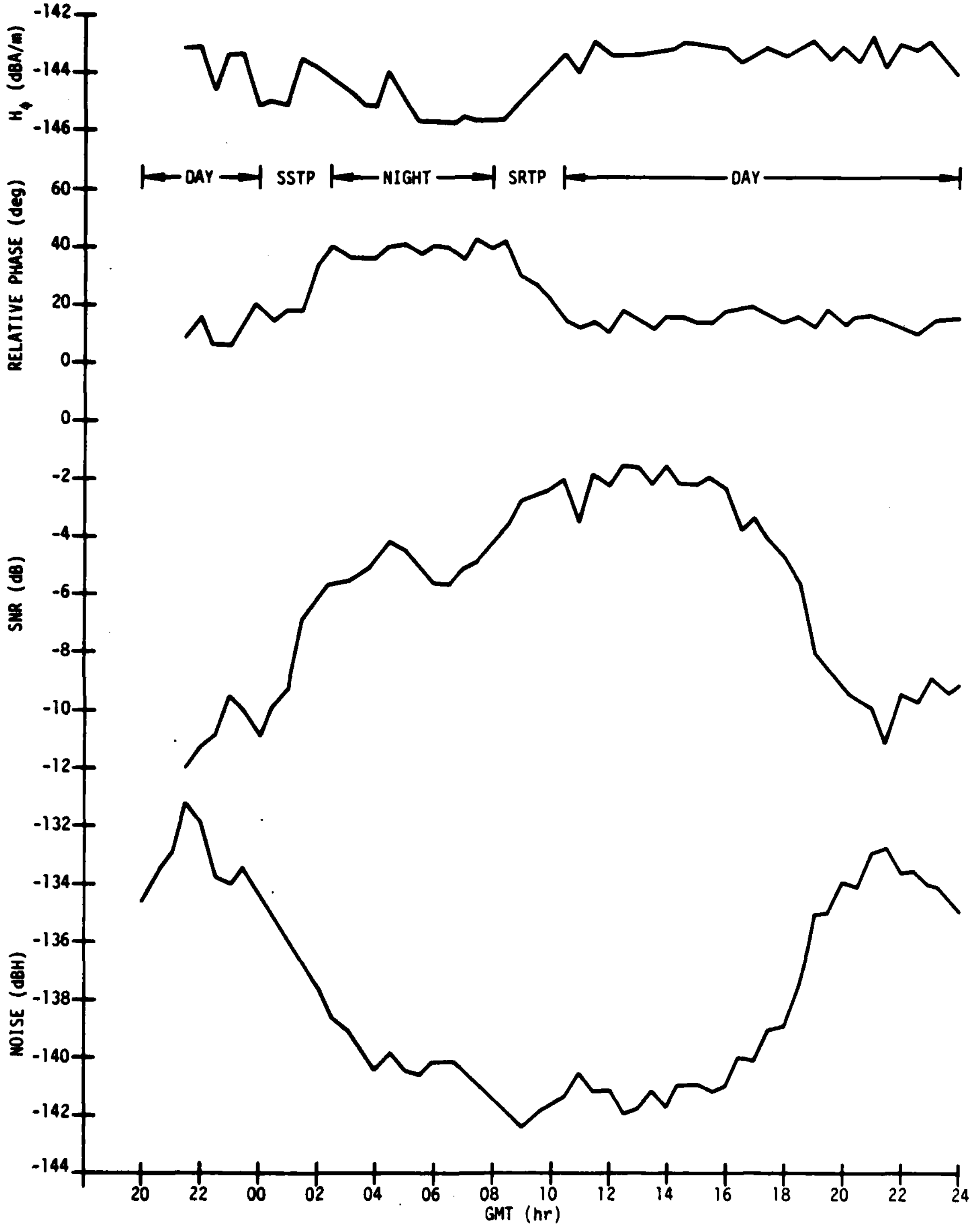

Figure A-23. Connecticut Data Versus GMT
(ψ = 291 deg), 26 May 1977

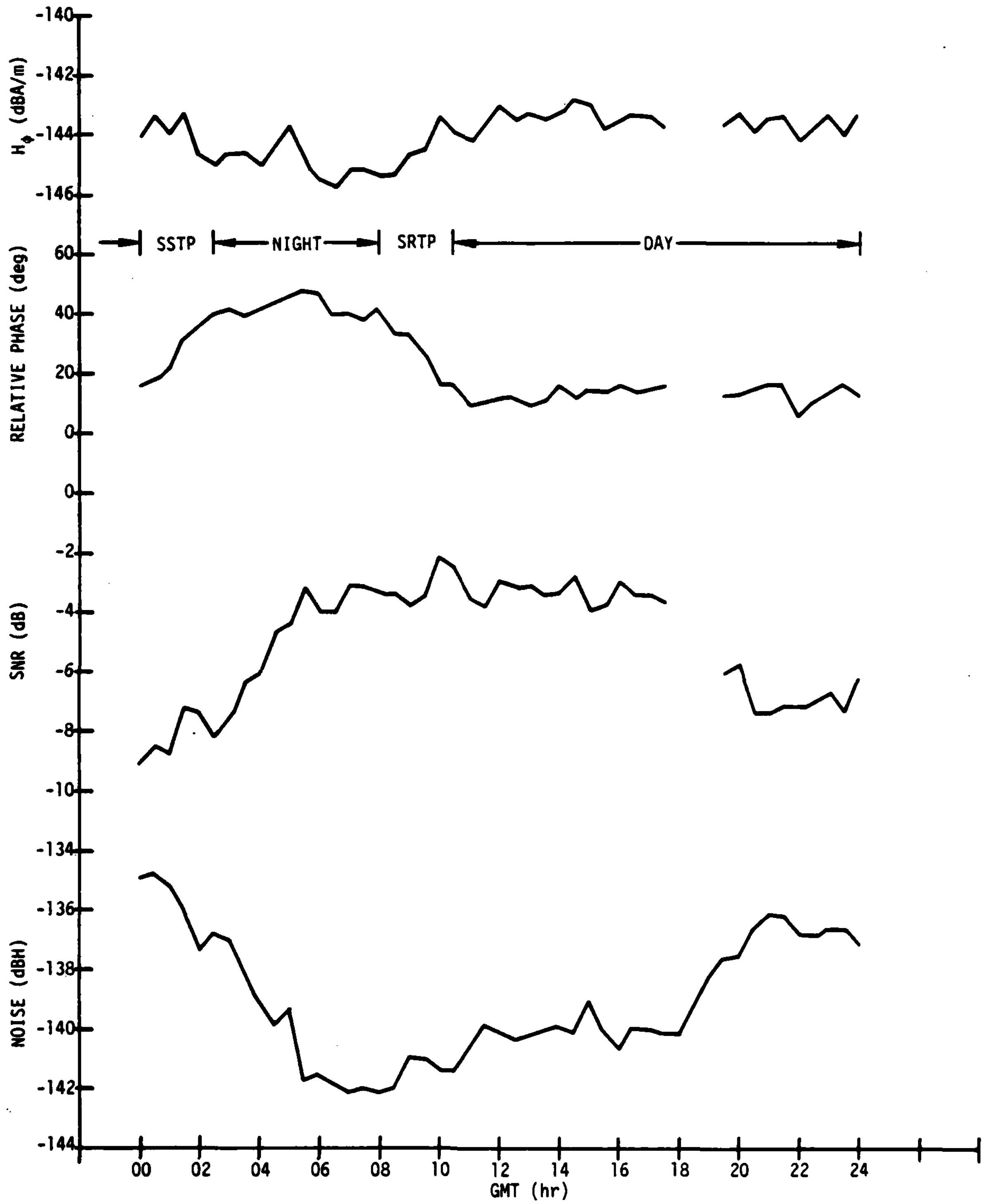

Figure A-24. Connecticut Data Versus GMT
(ψ = 291 deg), 27 May 1977

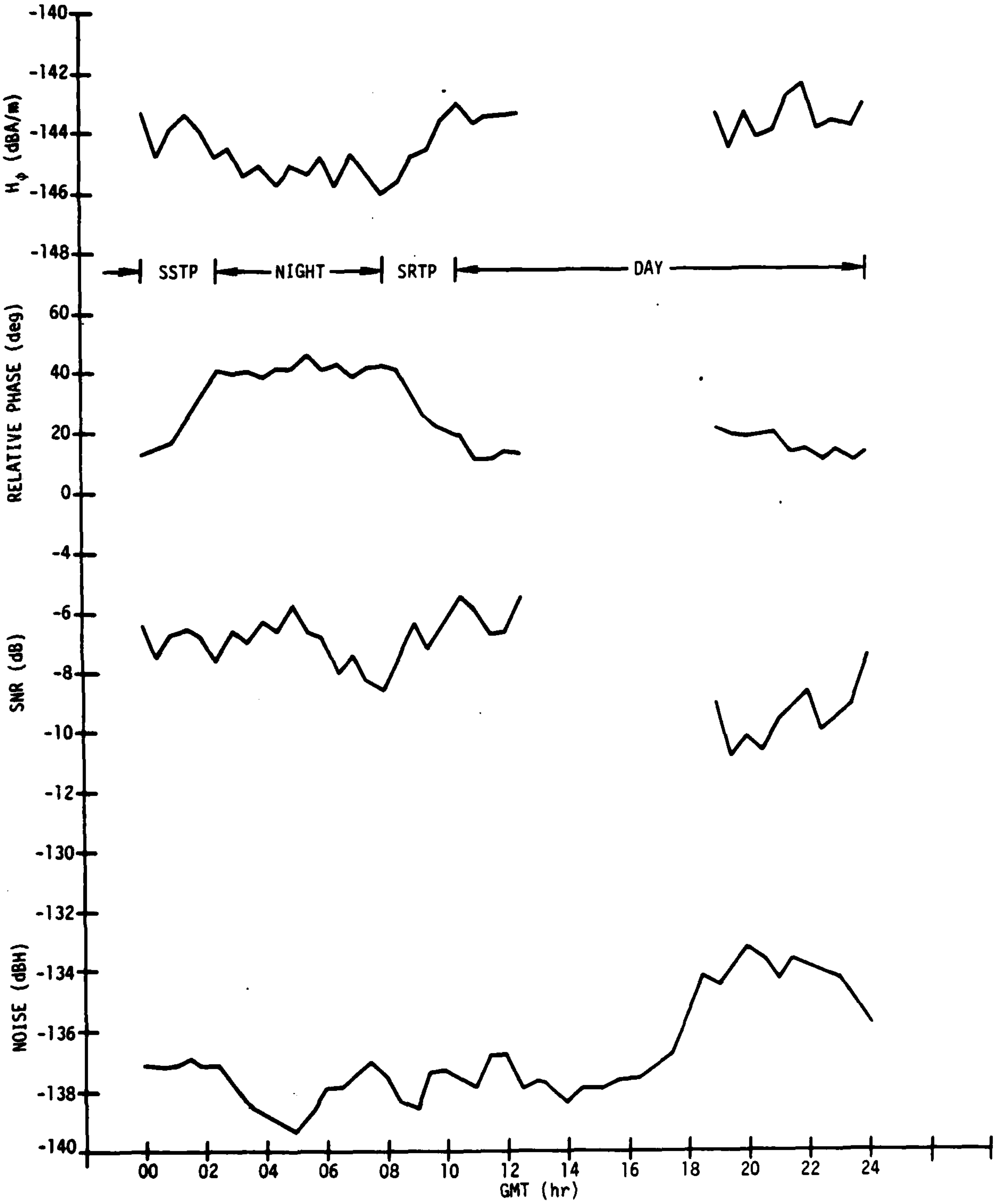

Figure A-25. Connecticut Data Versus GMT
(ψ = 291 deg), 28 May 1977

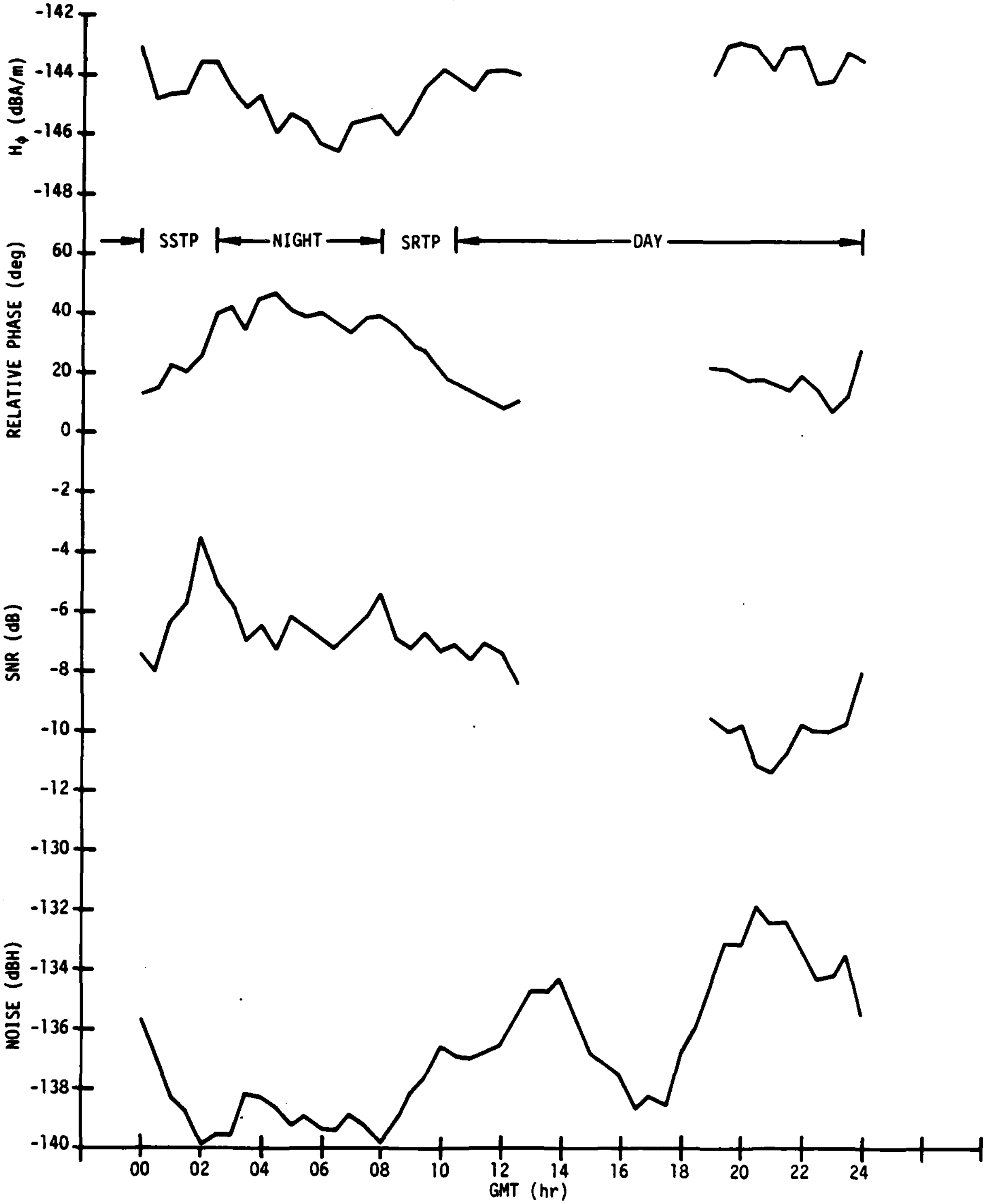

Figure A-26. Connecticut Data Versus GMT
(ψ = 291 deg), 29 May 1977

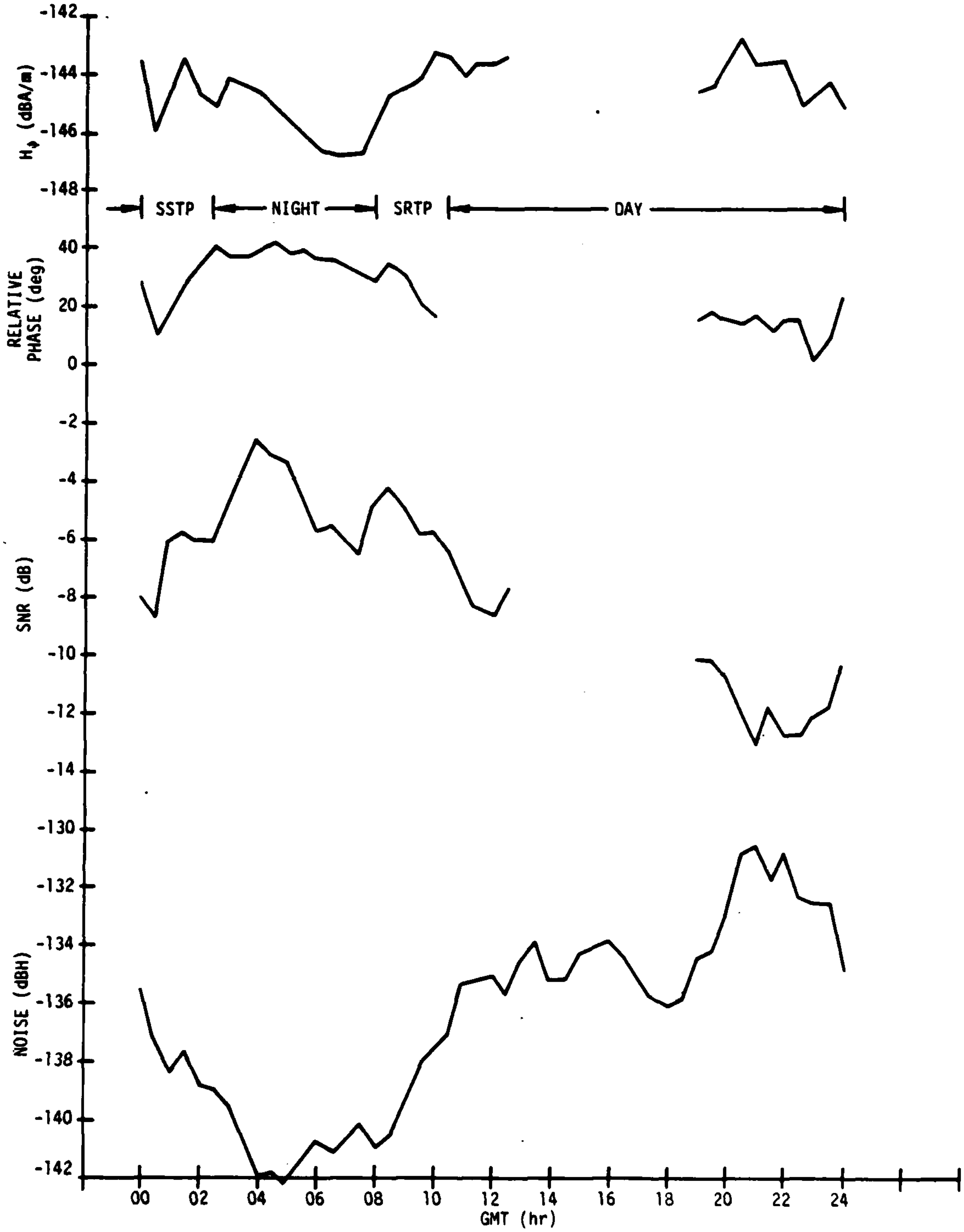

Figure A-27. Connecticut Data Versus GMT
(ψ = 291 deg), 30 May 1977

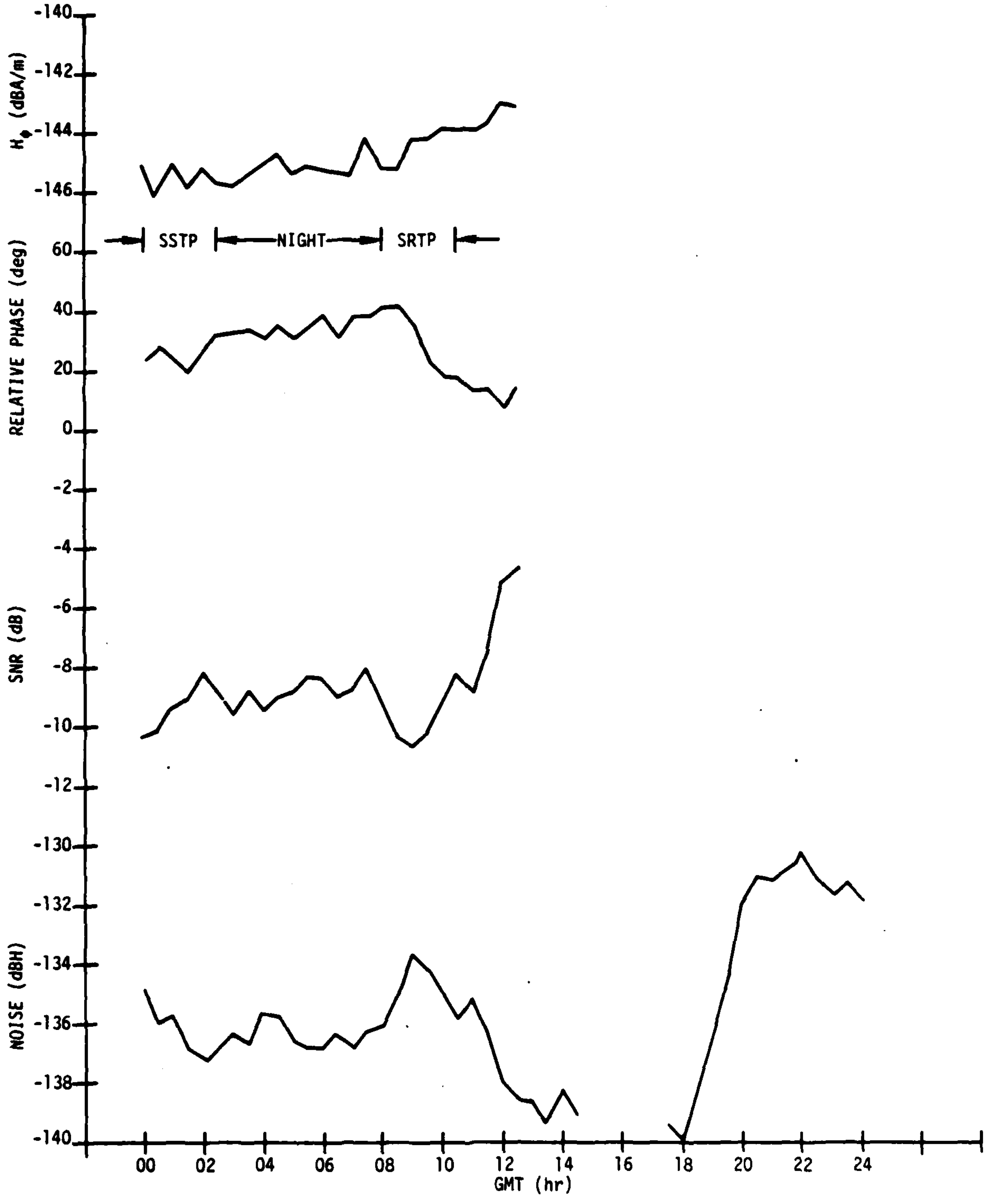

Figure A-28. Connecticut Data Versus GMT
(ψ = 291 deg), 31 May 1977

Appendix B

CONNECTICUT DAILY DATA, JUNE 1977

Daily plots of Connecticut signal-strength, effective-noise, and SNR values versus GMT for June 1977 are given in this appendix as figures B-1 through B-21.

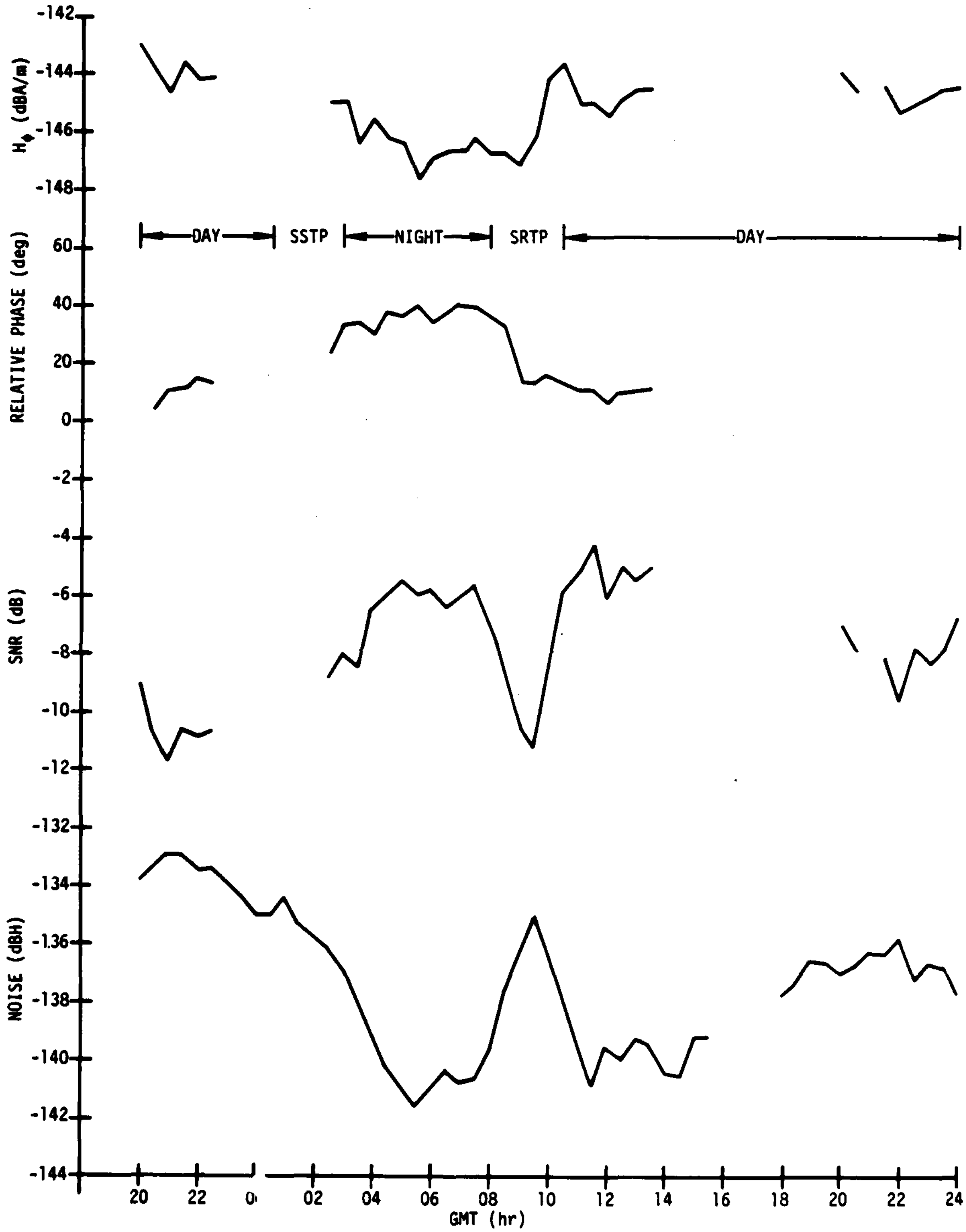

Figure B-1. Connecticut Data Versus GMT
(EW Antenna), 2 June 1977

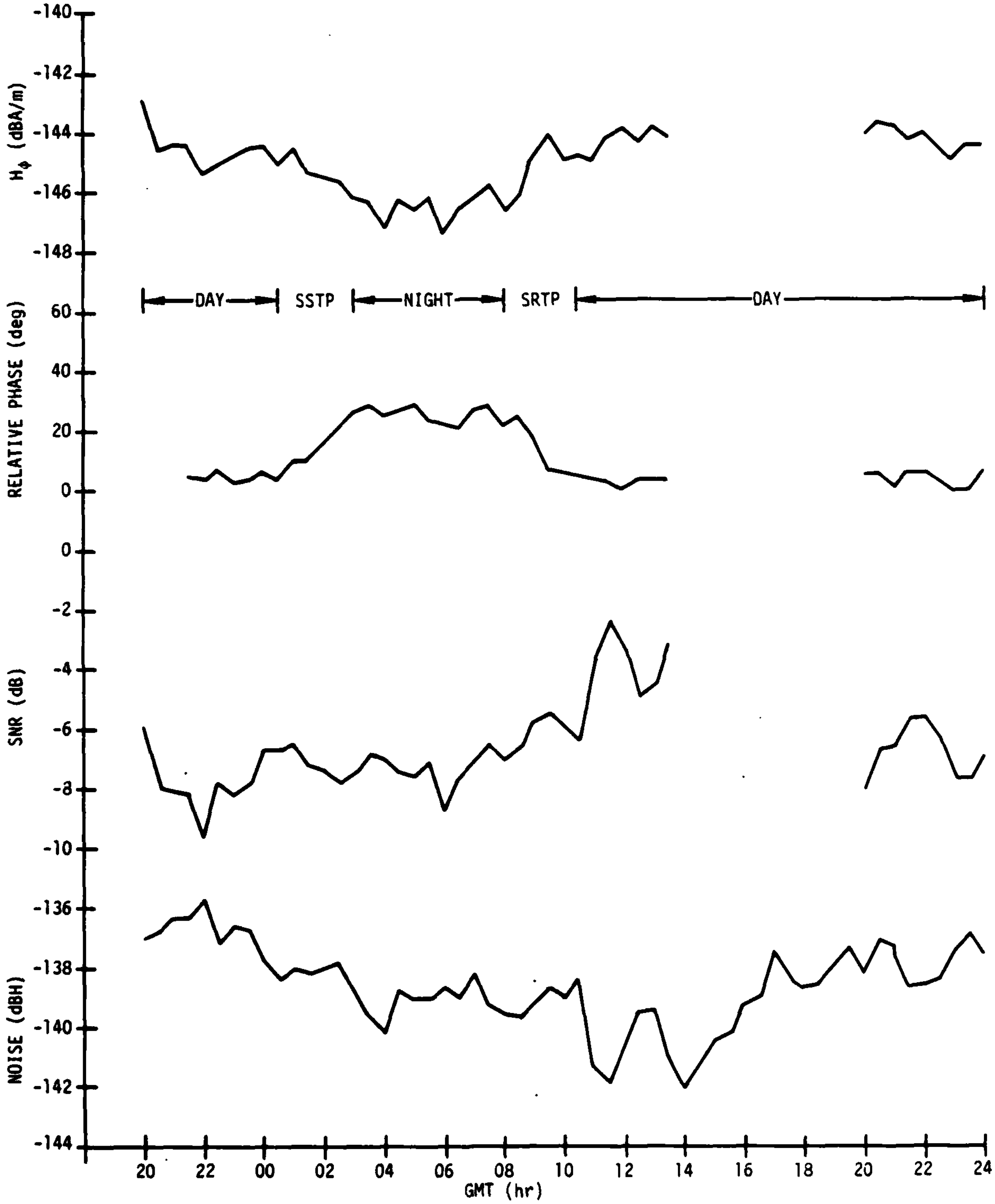

Figure B-2. Connecticut Data Versus GMT
(EW Antenna), 3 June 1977

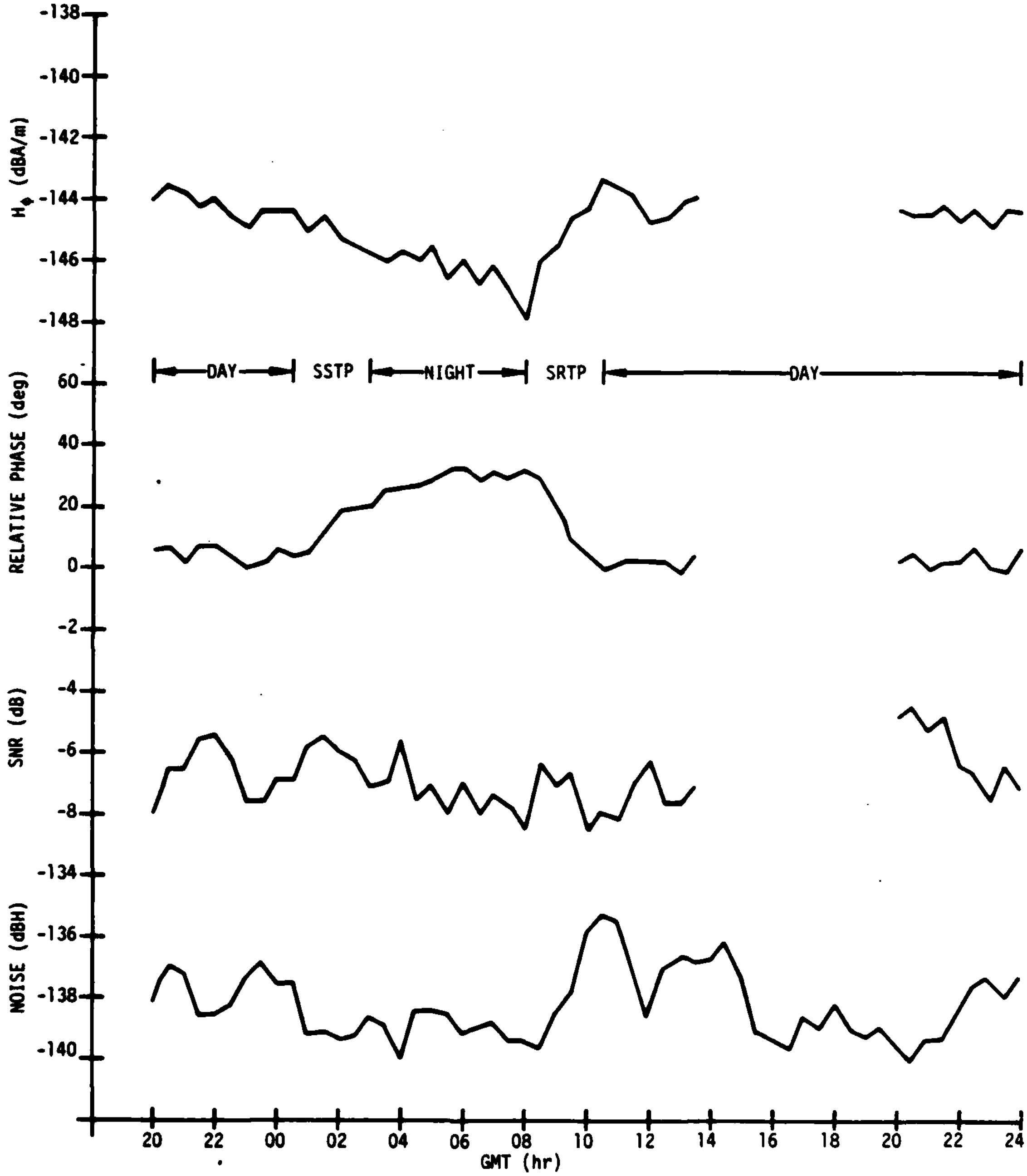

Figure B-3. Connecticut Data Versus GMT
(EW Antenna), 4 June 1977

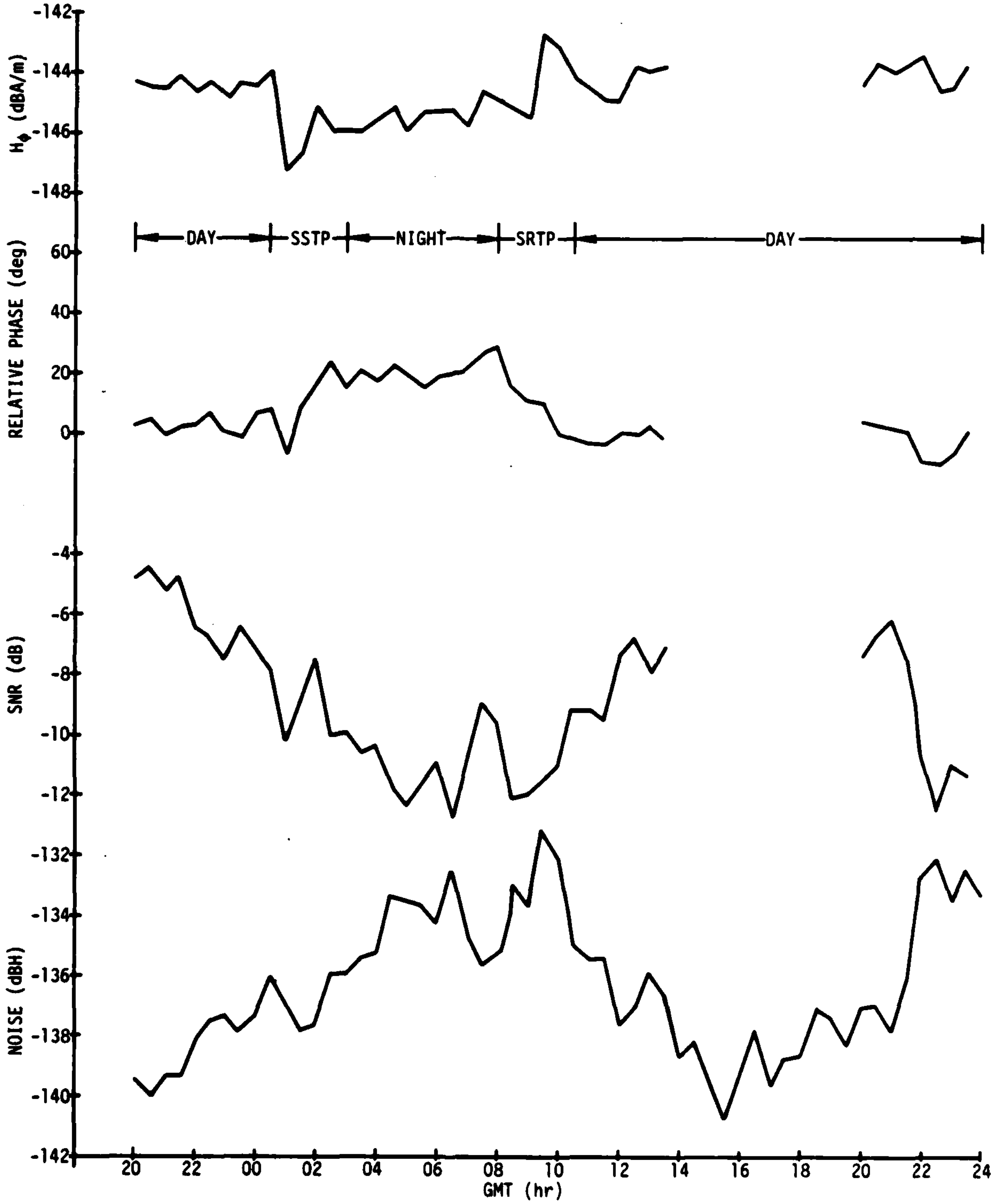

Figure B-4. Connecticut Data Versus GMT
(EW Antenna), 5 June 1977

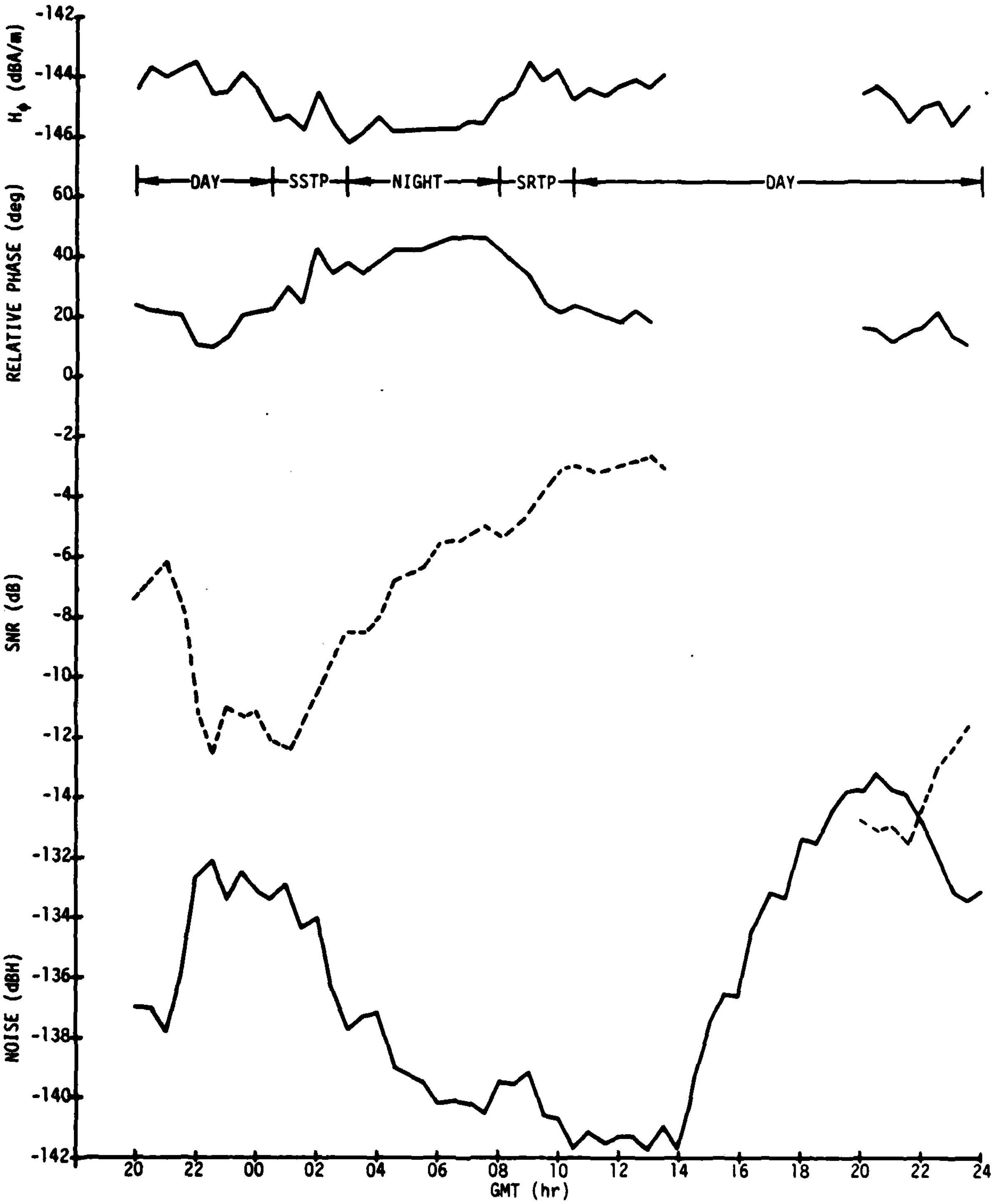

Figure B-5. Connecticut Data Versus GMT
(EW Antenna), 6 June 1977

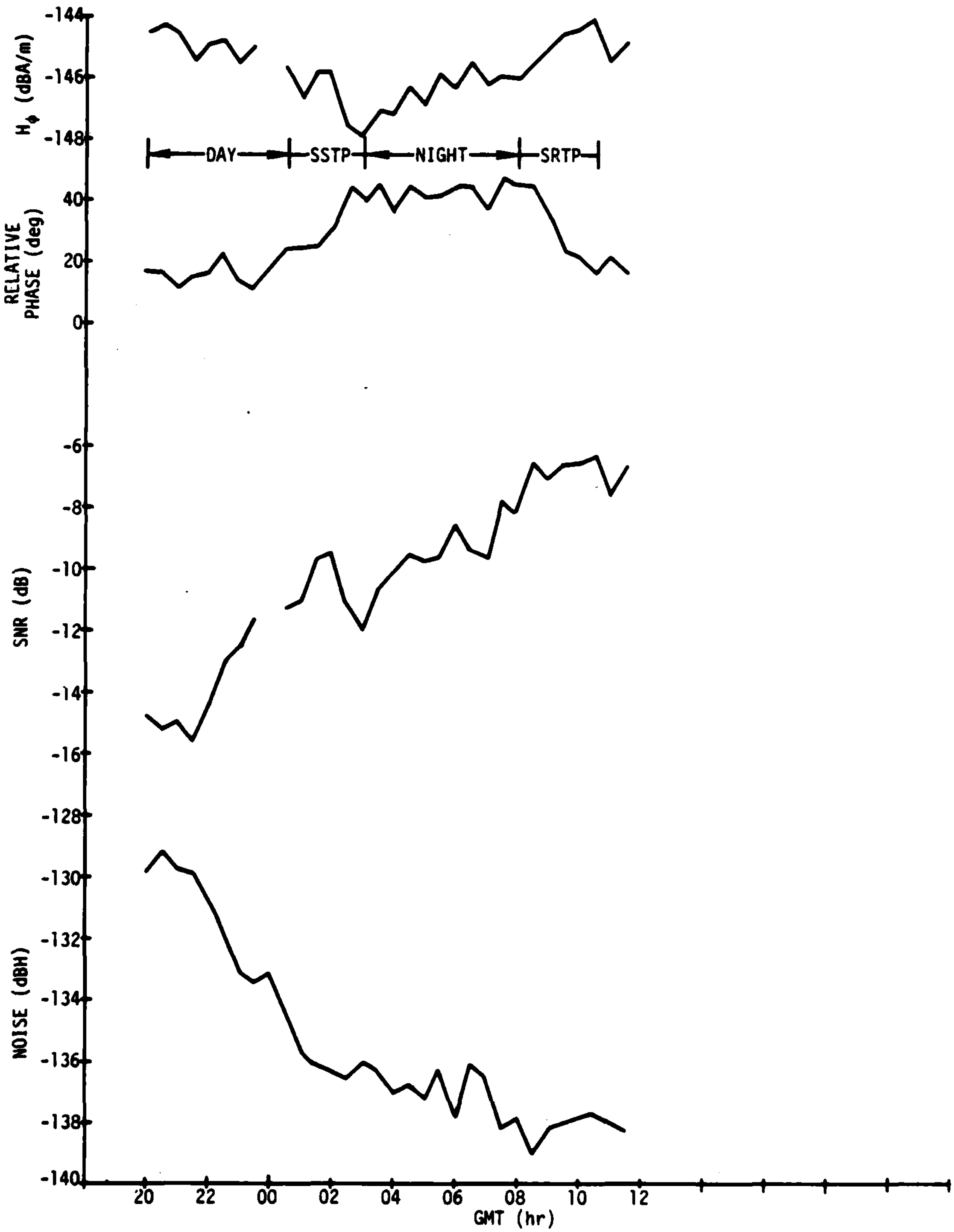

Figure B-6. Connecticut Data Versus GMT
(EW Antenna), 7 June 1977

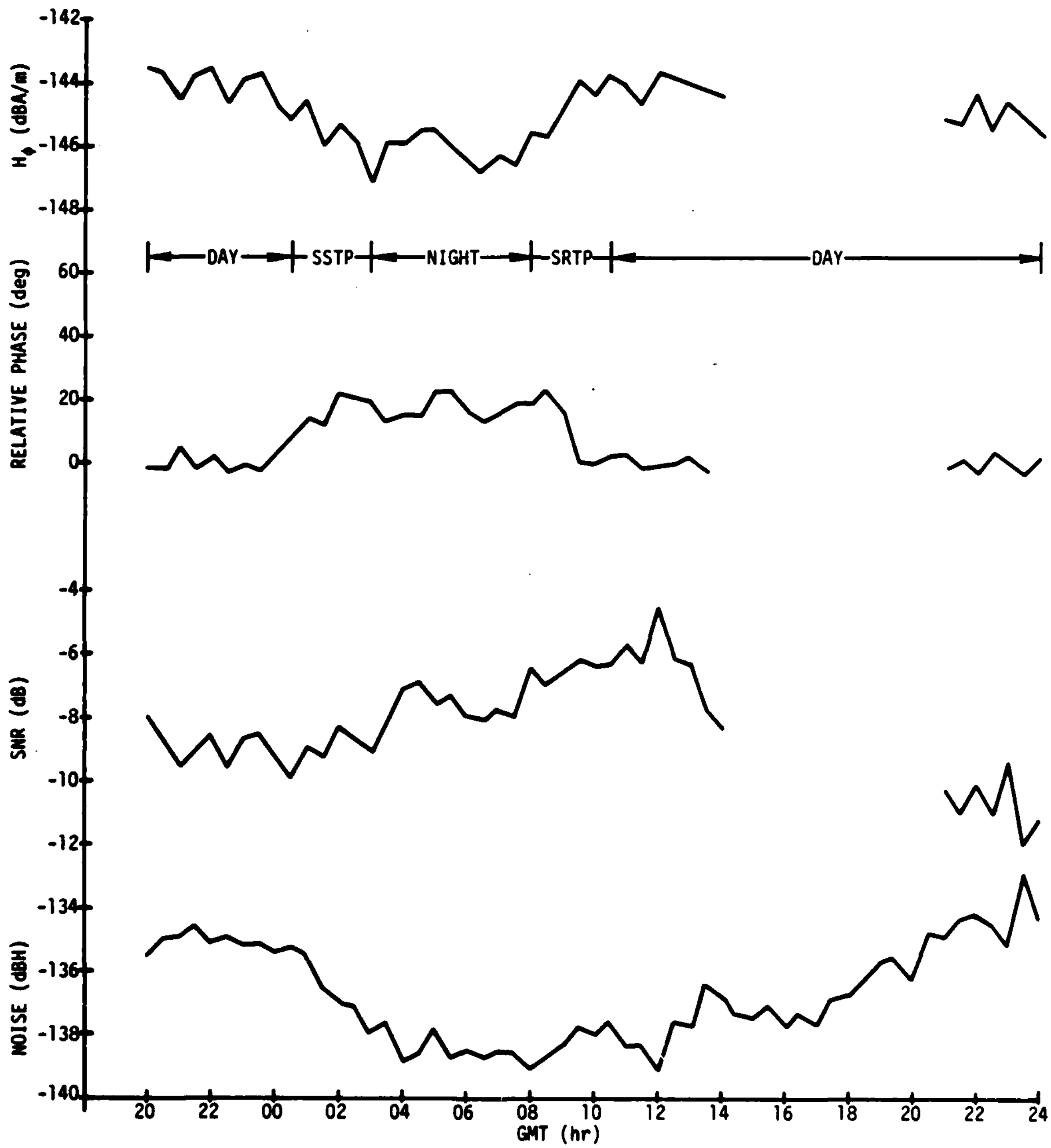

Figure B-7. Connecticut Data Versus GMT
(EW Antenna), 8 June 1977

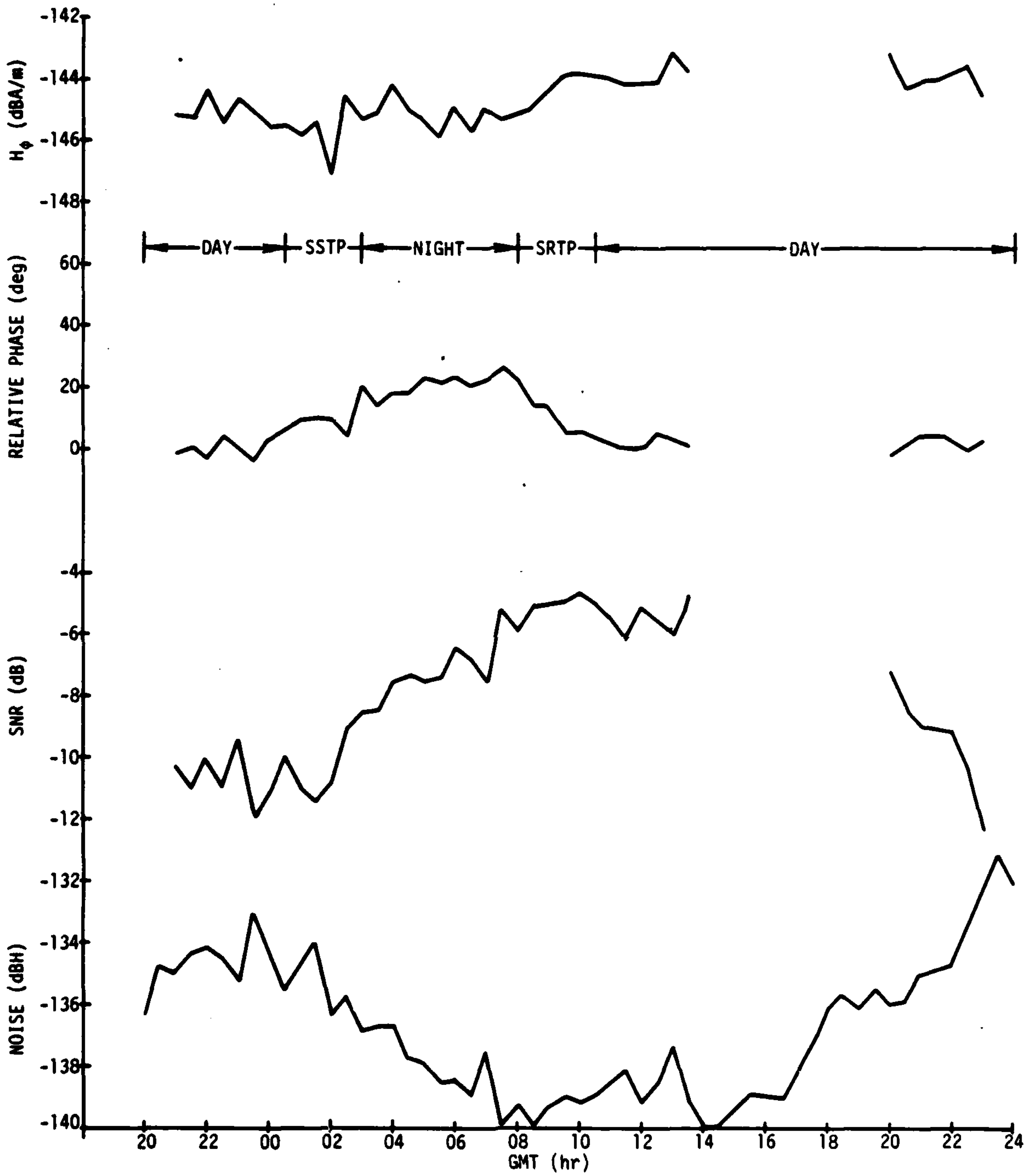

Figure B-8. Connecticut Data Versus GMT
(EW Antenna), 9 June 1977

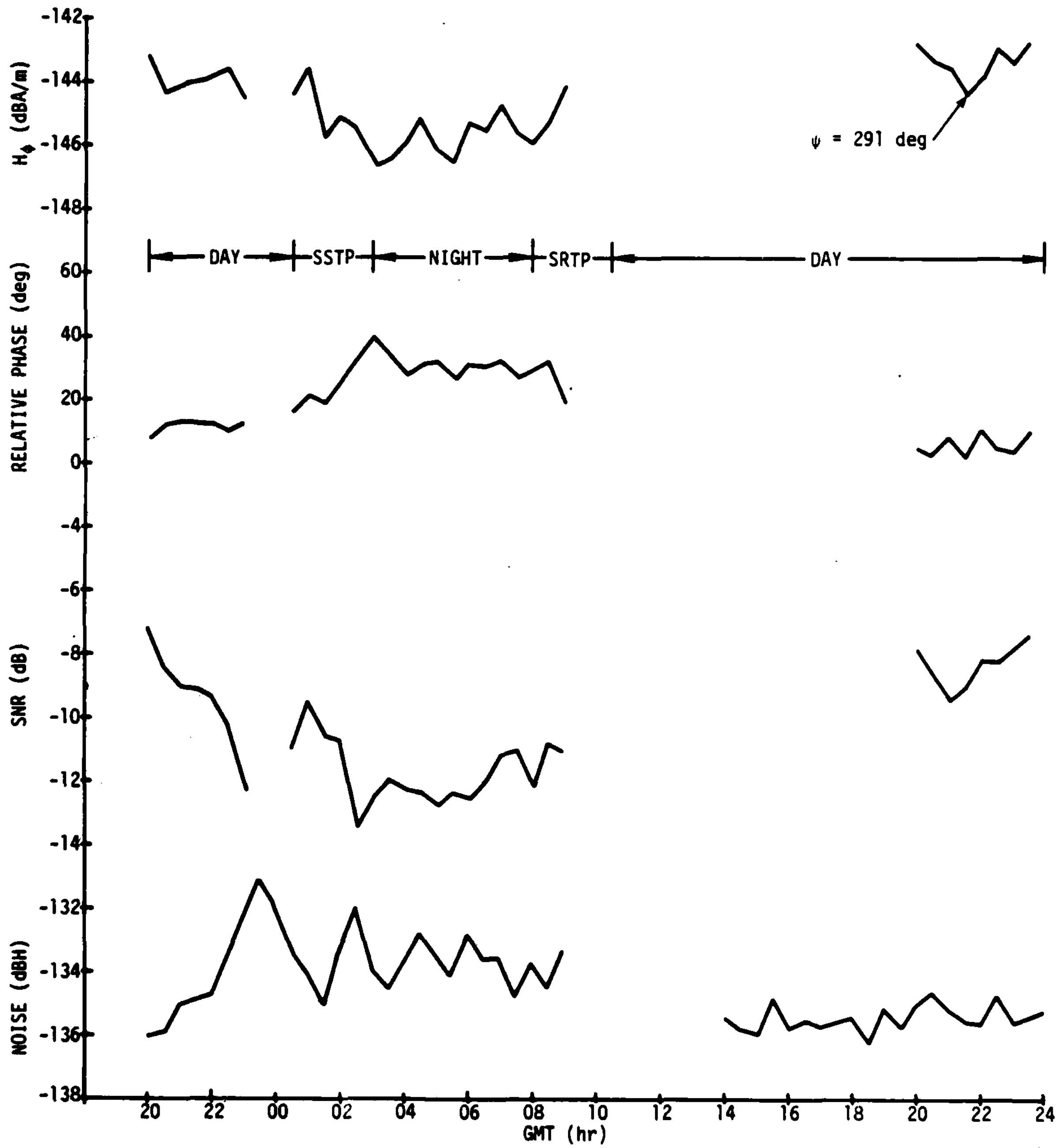

Figure B-9. Connecticut Data Versus GMT
(EW Antenna), 10 June 1977

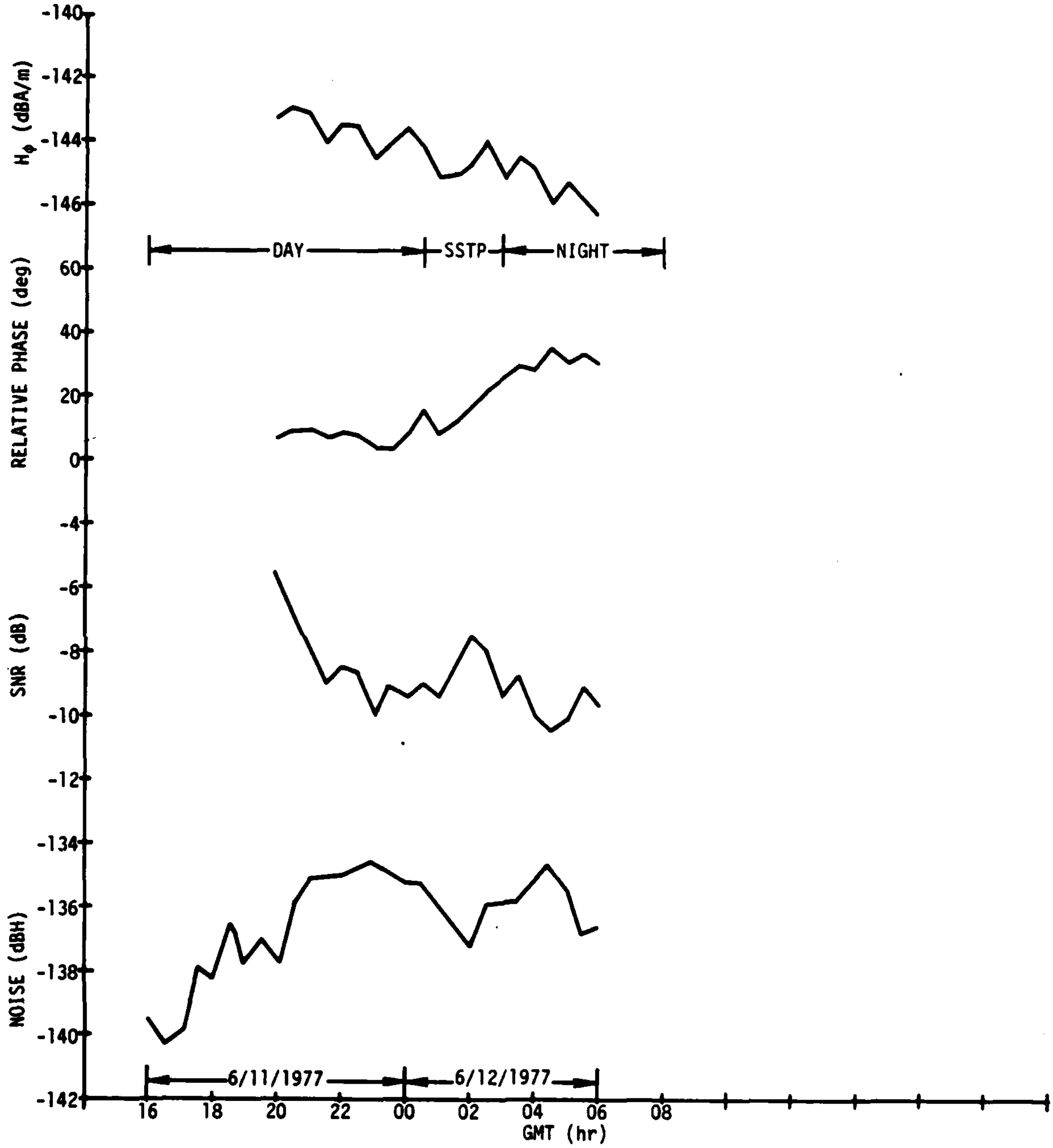

Figure B-10. Connecticut Data Versus GMT
(ψ = 291 deg), 11 and 12 June 1977

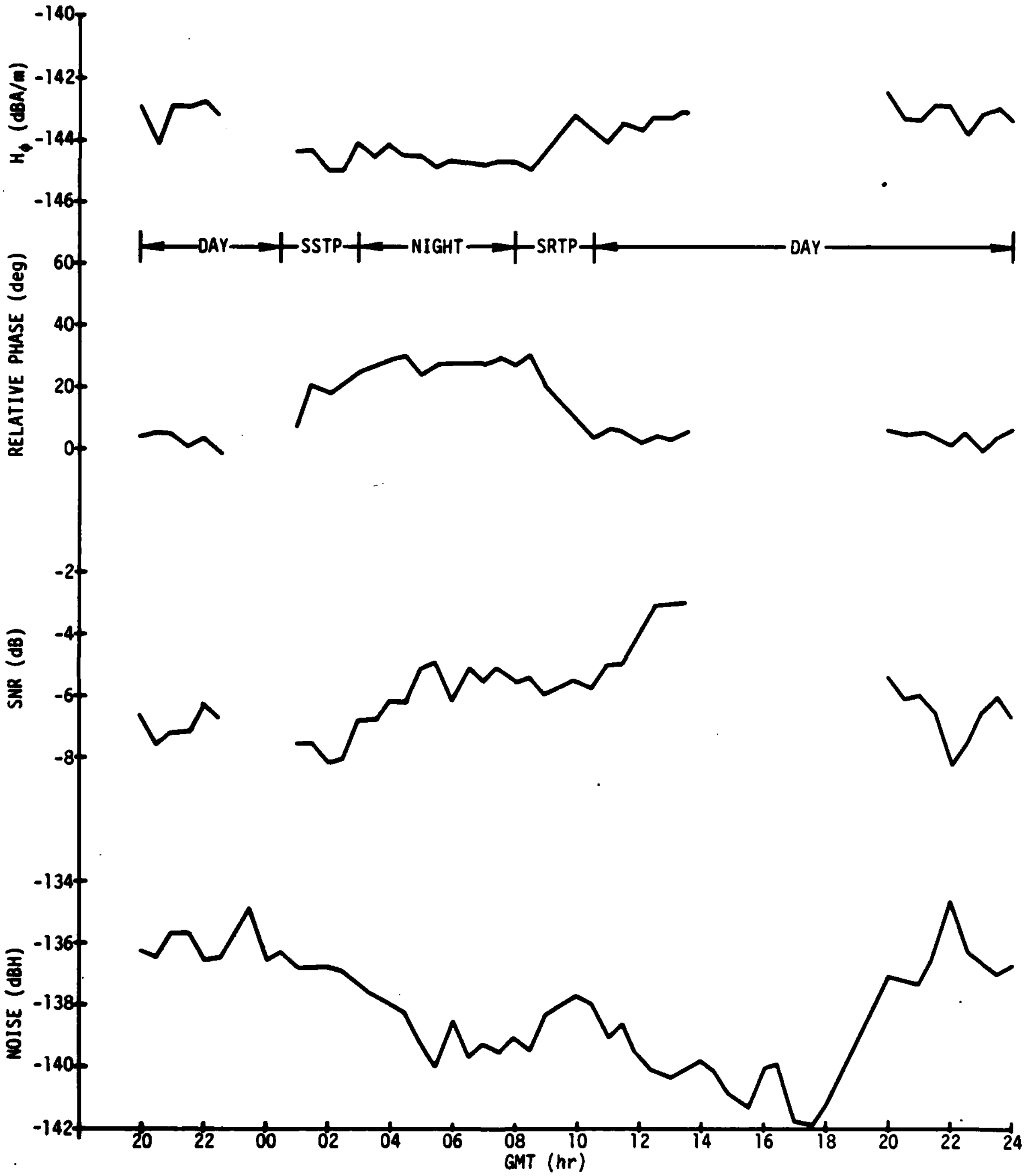

Figure B-11. Connecticut Data Versus GMT
(ψ = 291 deg), 15 June 1977

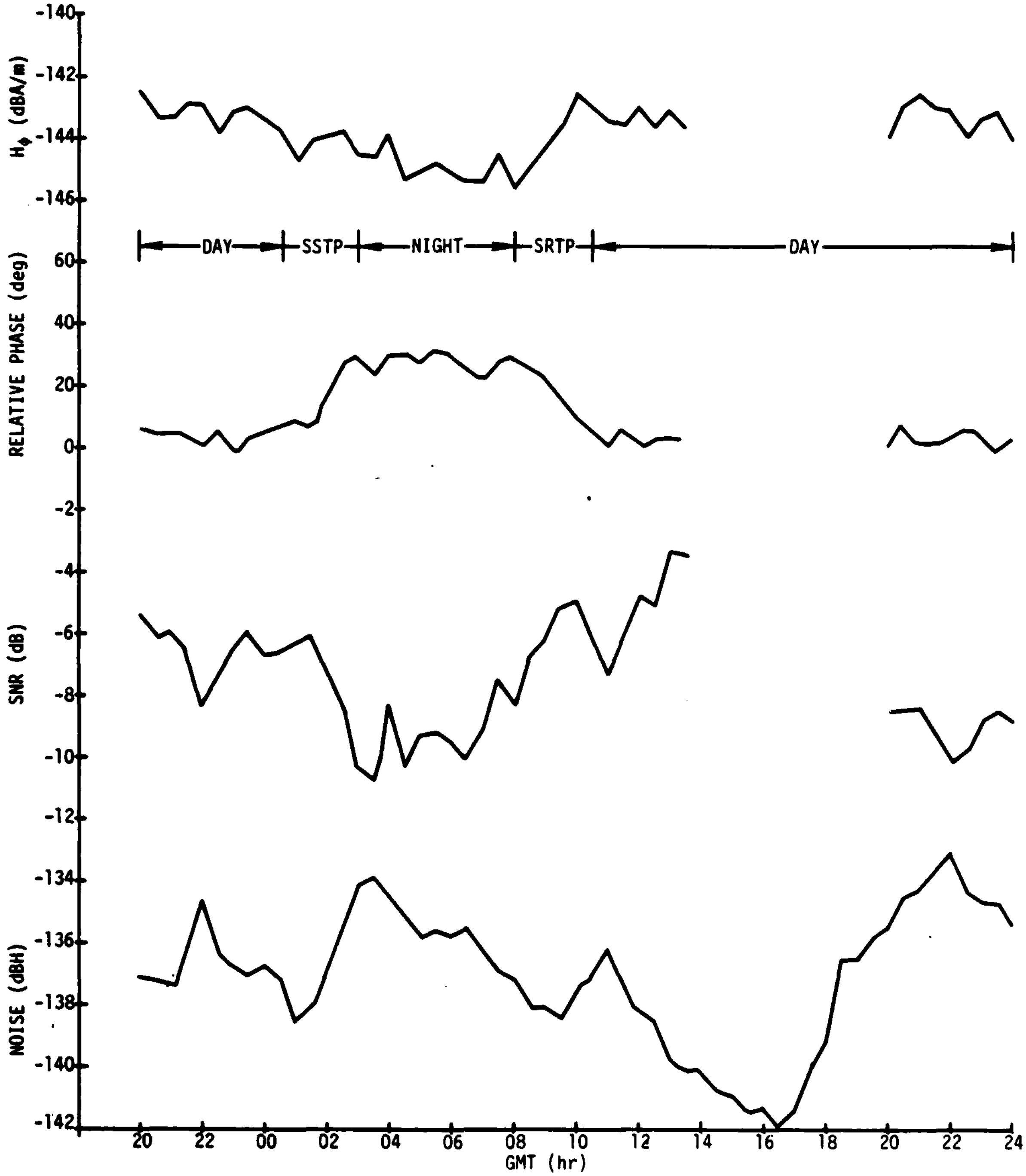

Figure B-12. Connecticut Data Versus GMT
(ψ = 291 deg), 16 June 1977

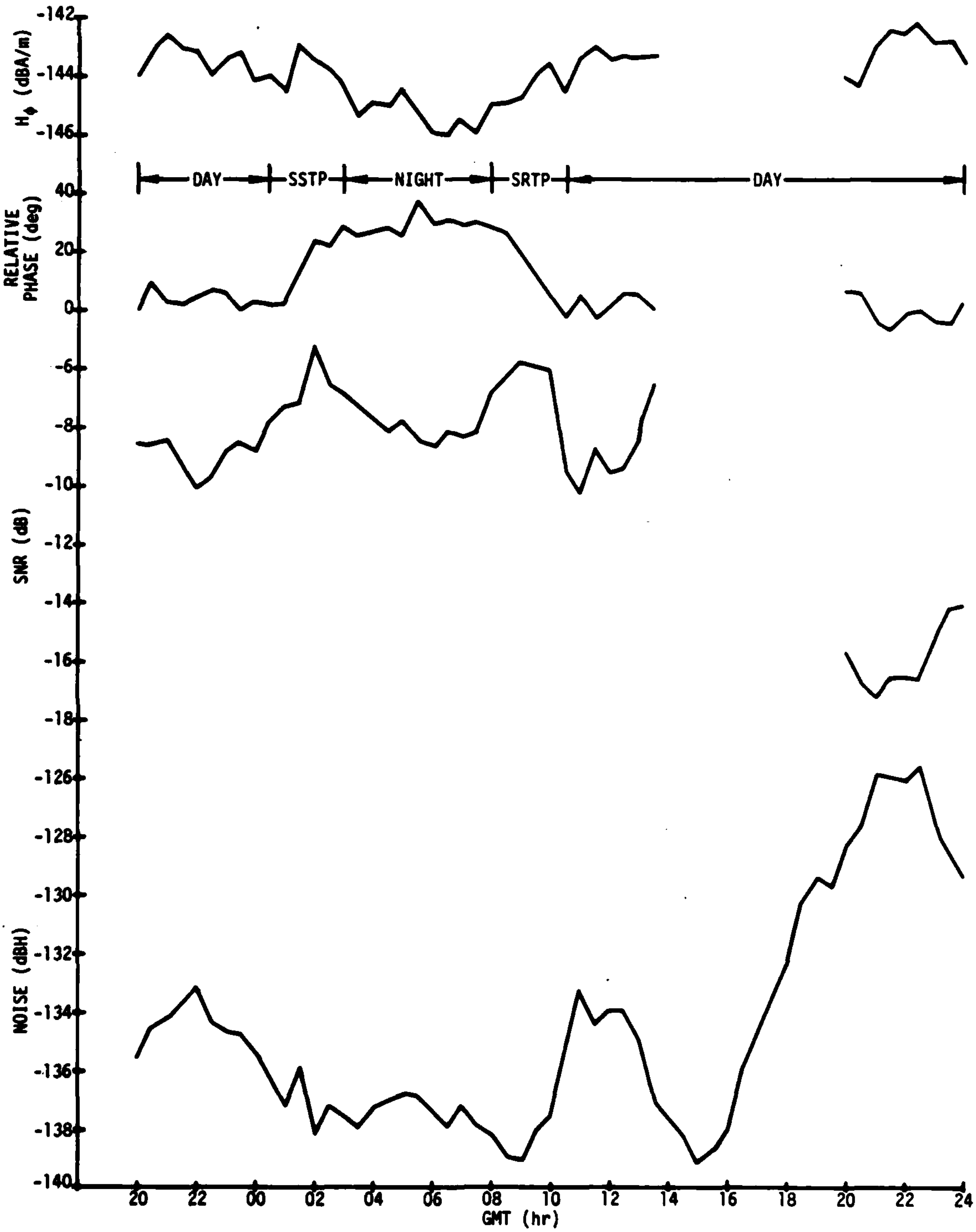

Figure B-13. Connecticut Data Versus GMT
(ψ = 291 deg), 17 June 1977

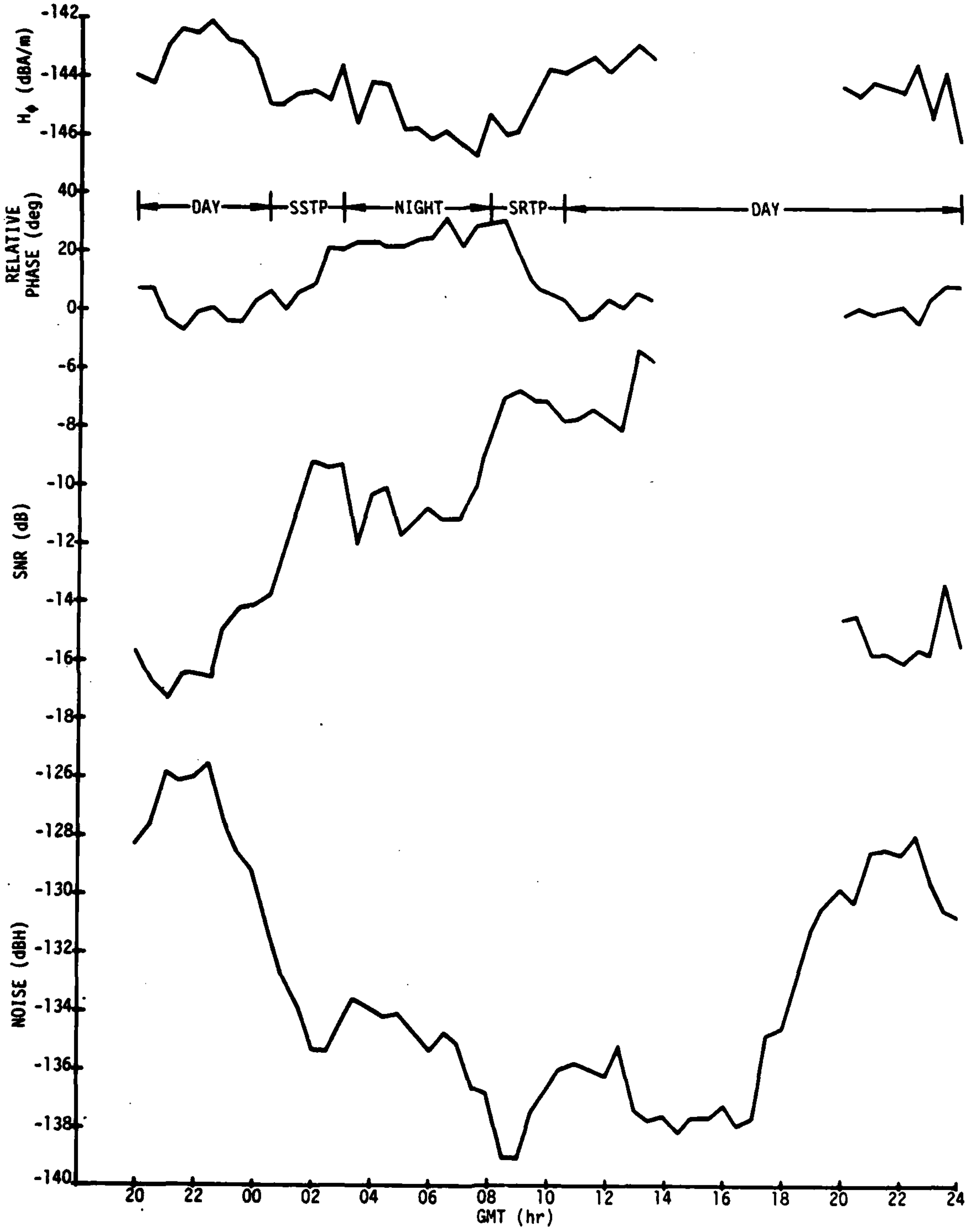

Figure B-14. Connecticut Data Versus GMT
(ψ = 291 deg), 18 June 1977

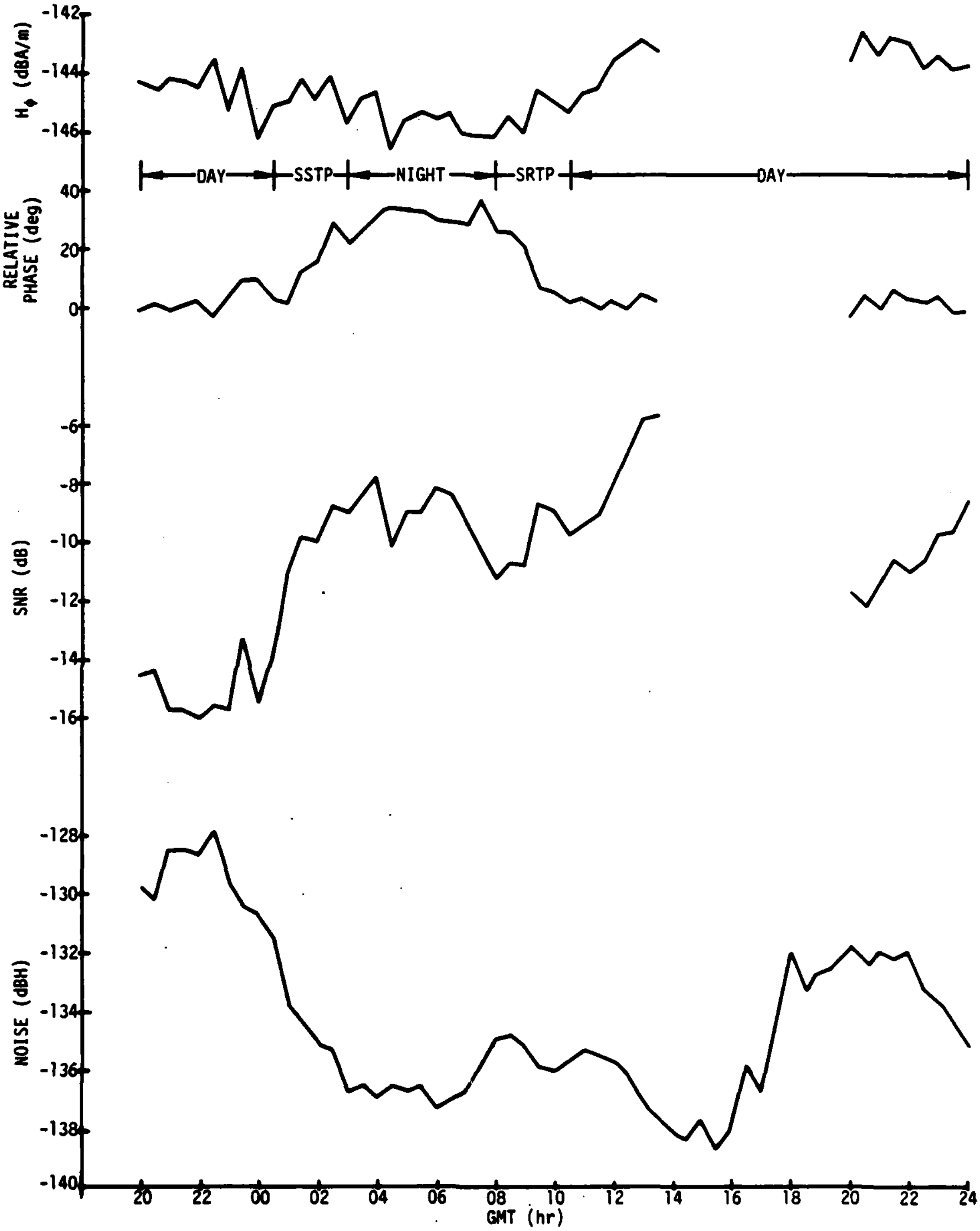

Figure B-15. Connecticut Data Versus GMT
(ψ = 291 deg), 19 June 1977

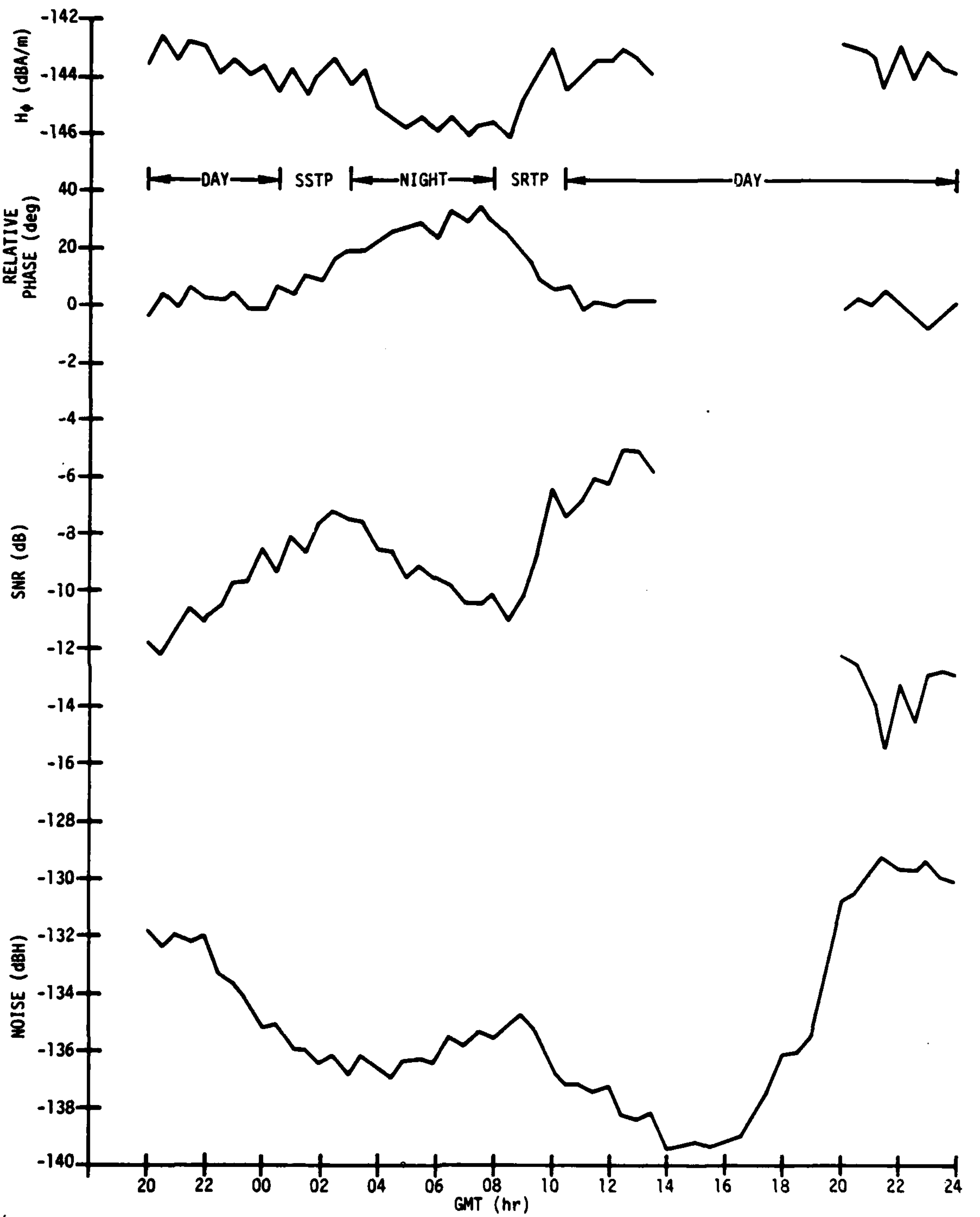

Figure B-16. Connecticut Data Versus GMT
(ψ = 291 deg), 20 June 1977

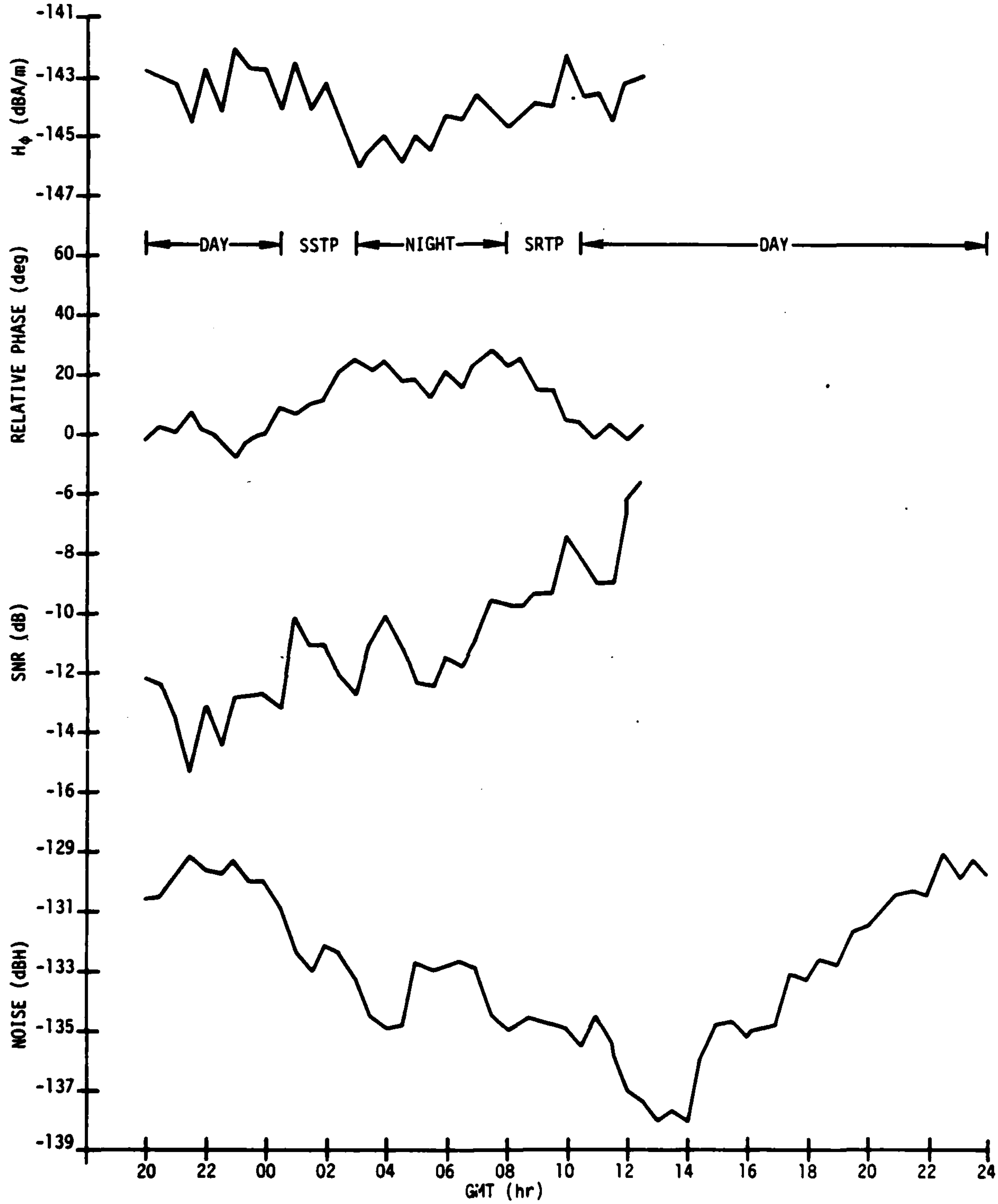

Figure B-17. Connecticut Data Versus GMT (ψ = 291 deg), 21 June 1977

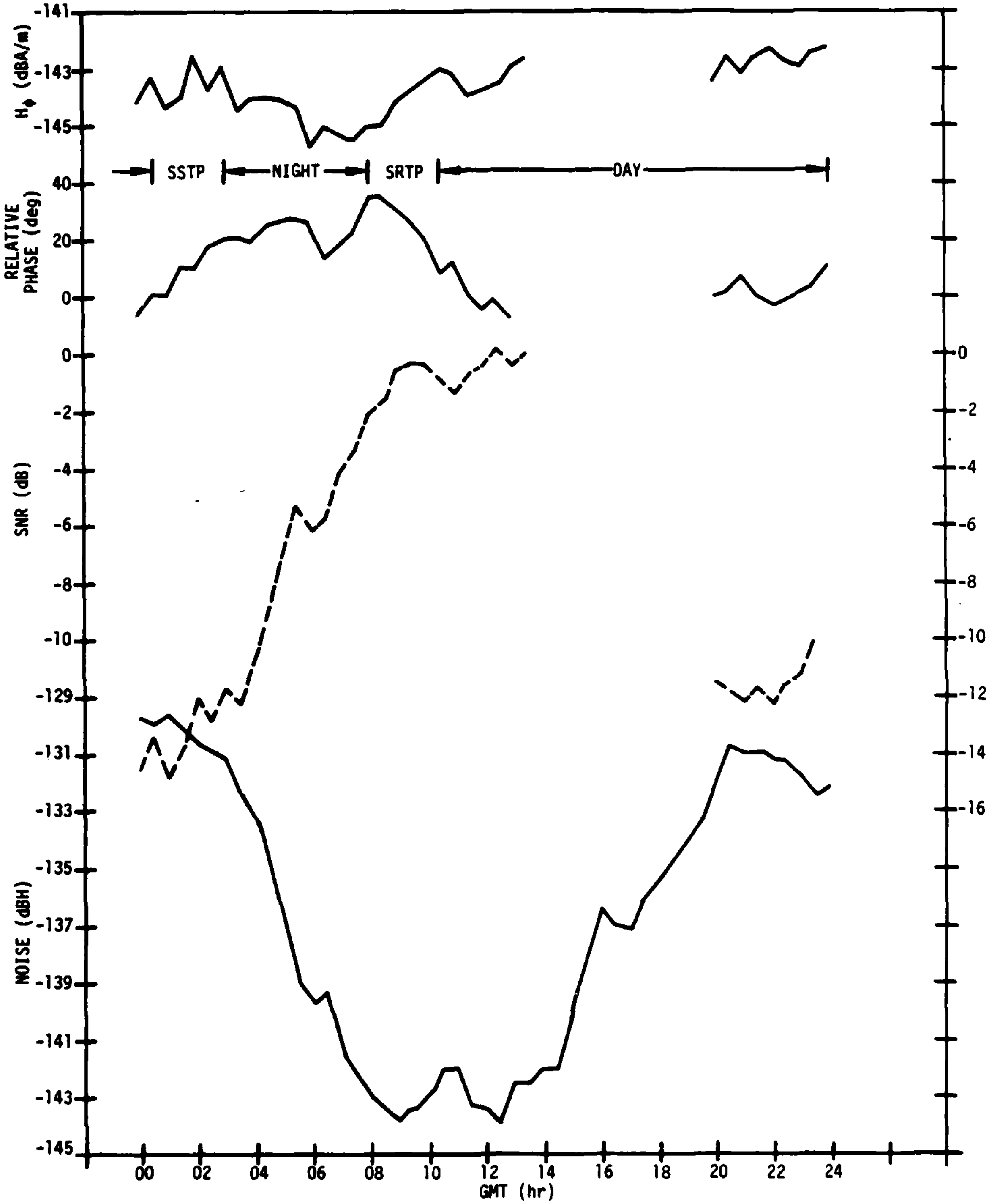

Figure B-18. Connecticut Data Versus GMT
(ψ = 291 deg), 22 June 1977

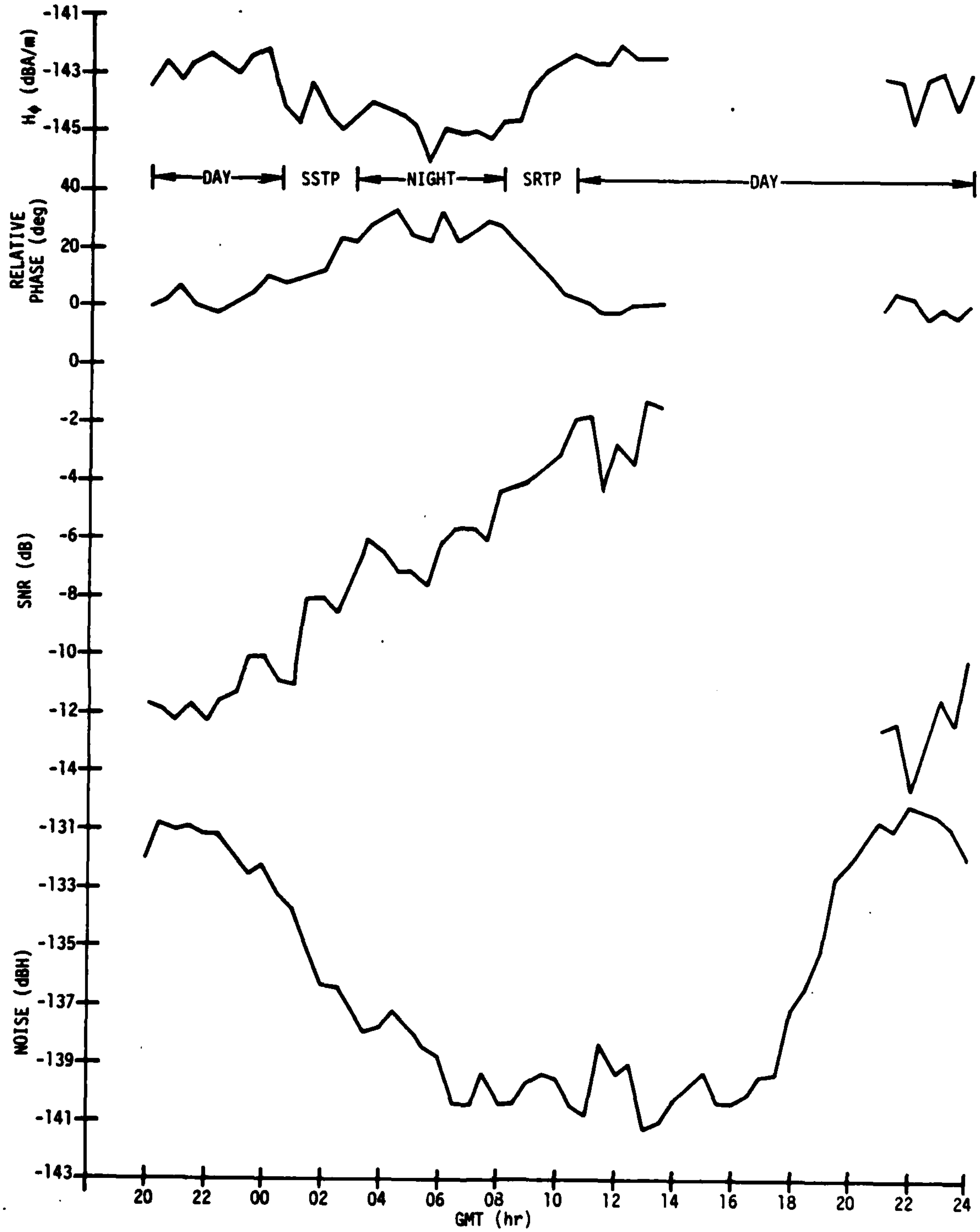

Figure B-19. Connecticut Data Versus GMT
(ψ = 291 deg), 23 June 1977

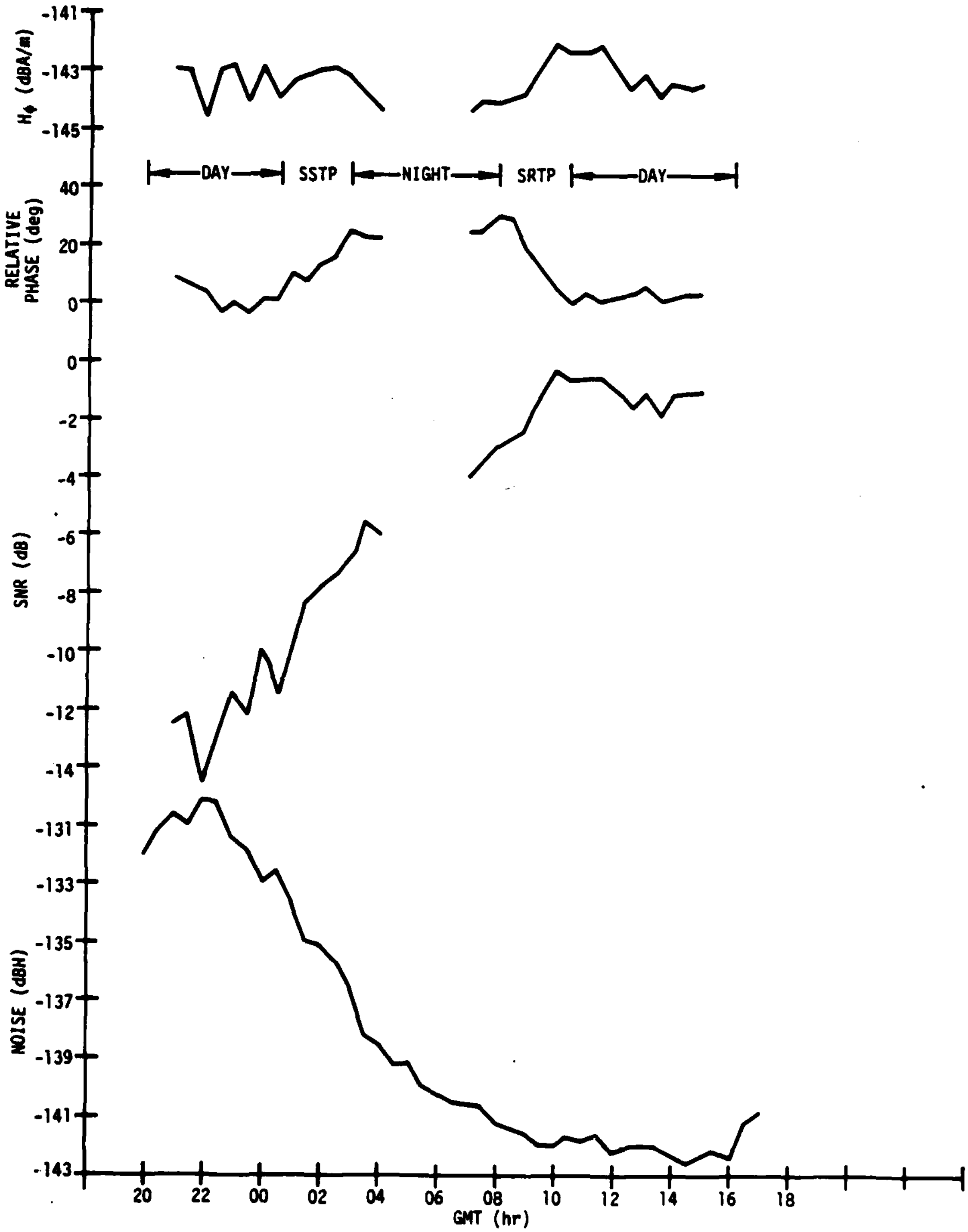

Figure B-20. Connecticut Data Versus GMT
(ψ = 291 deg), 24 June 1977

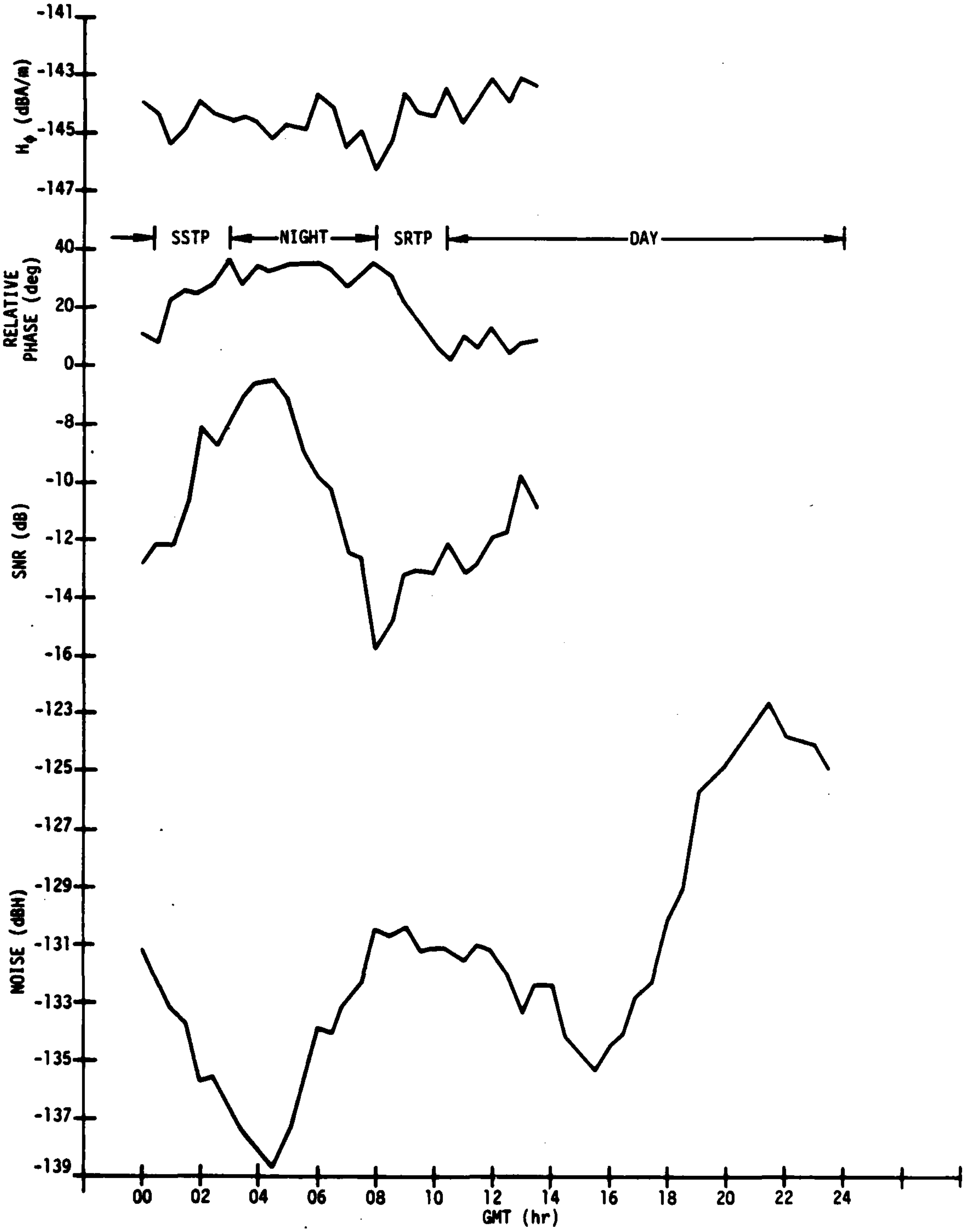

Figure B-21. Connecticut Data Versus GMT
(ψ = 291 deg), 30 June 1977

Appendix C

CONNECTICUT DAILY DATA, JULY 1977

Daily plots of Connecticut signal-strength, effective-noise, and SNR values versus GMT for July 1977 are given in this appendix as figures C-1 through C-20.

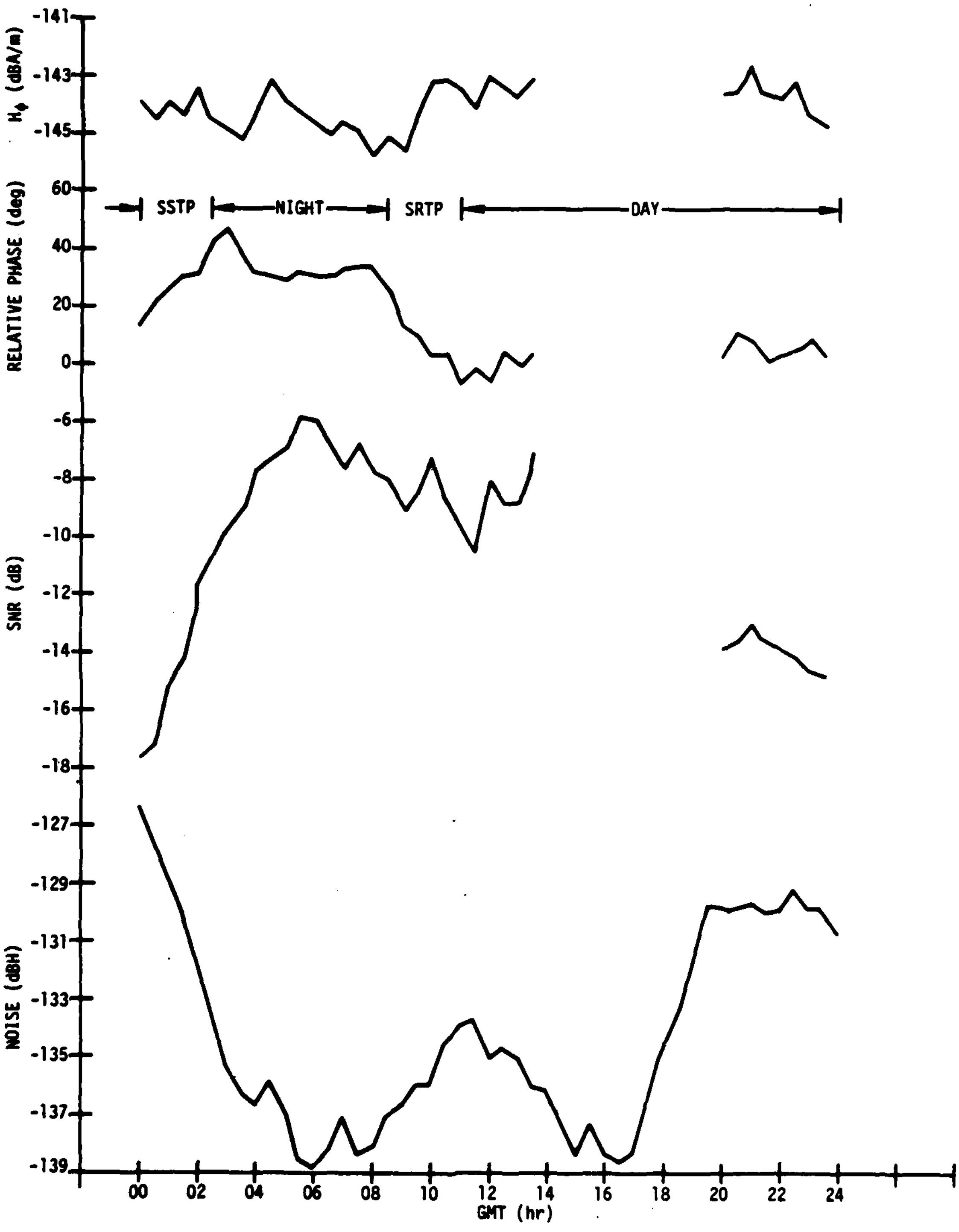

Figure C-1. Connecticut Data Versus GMT
(ψ = 291 deg), 1 July 1977

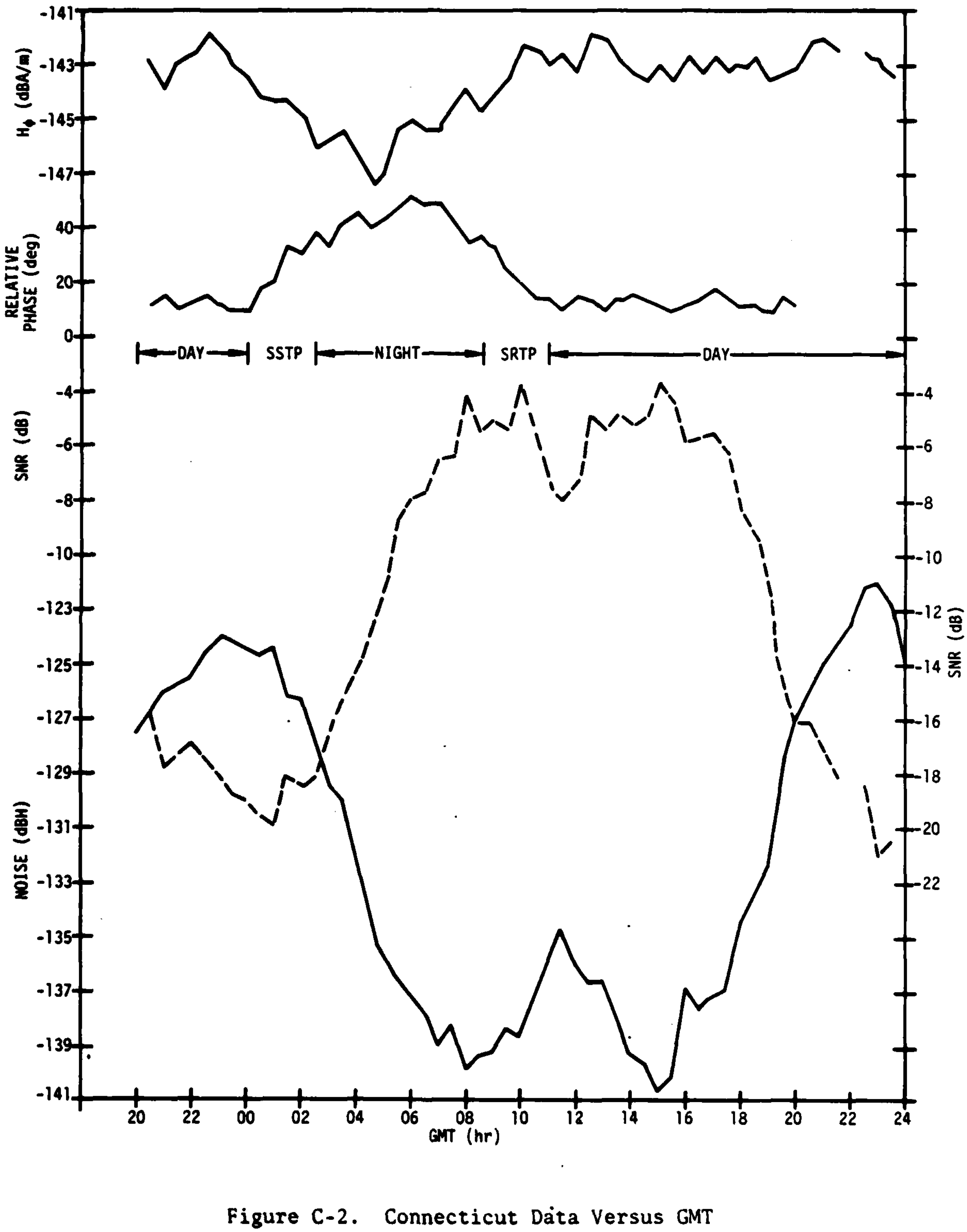

Figure C-2. Connecticut Data Versus GMT
(ψ = 291 deg), 7 July 1977

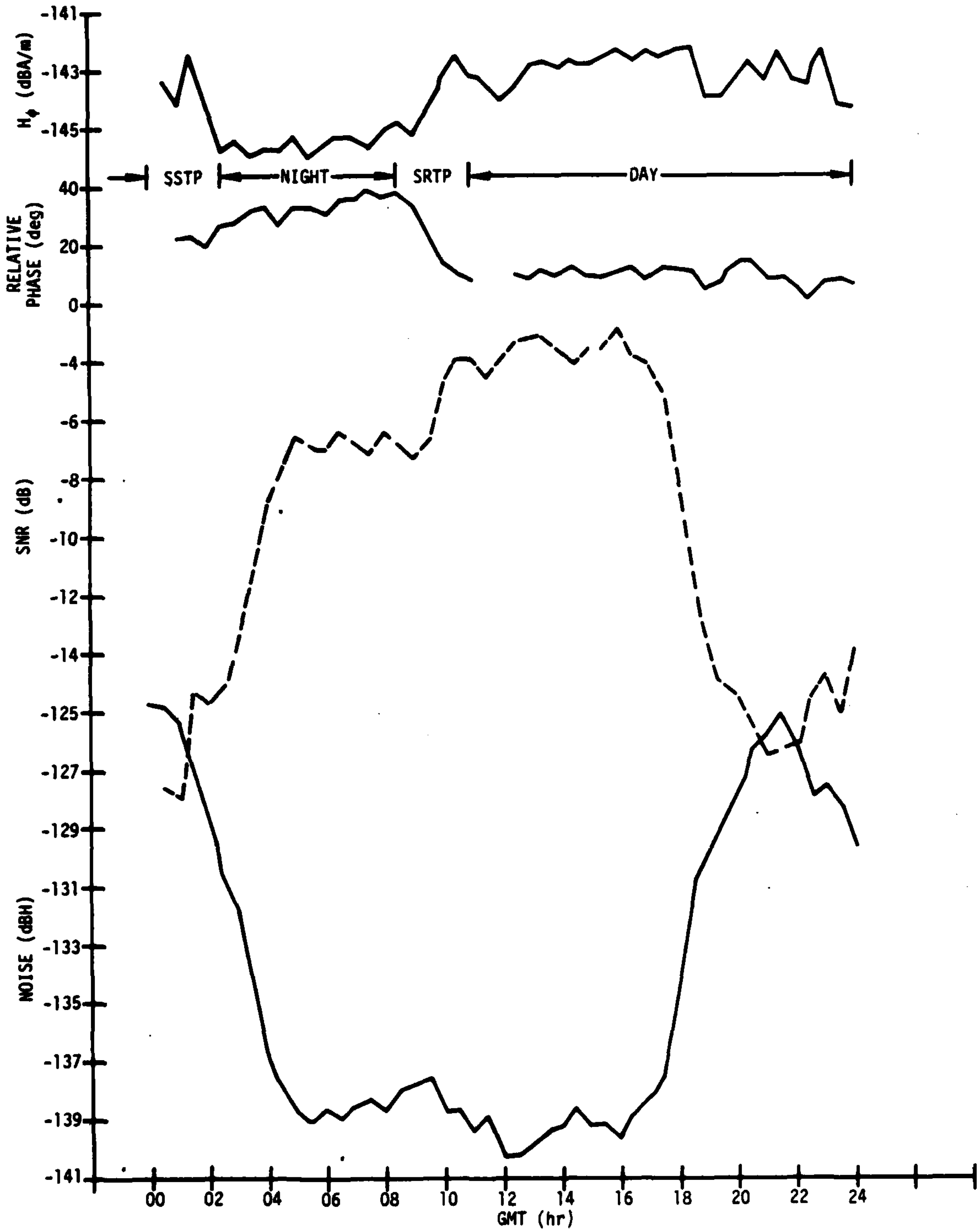

Figure C-3. Connecticut Data Versus GMT
(ψ = 291 deg), 8 July 1977

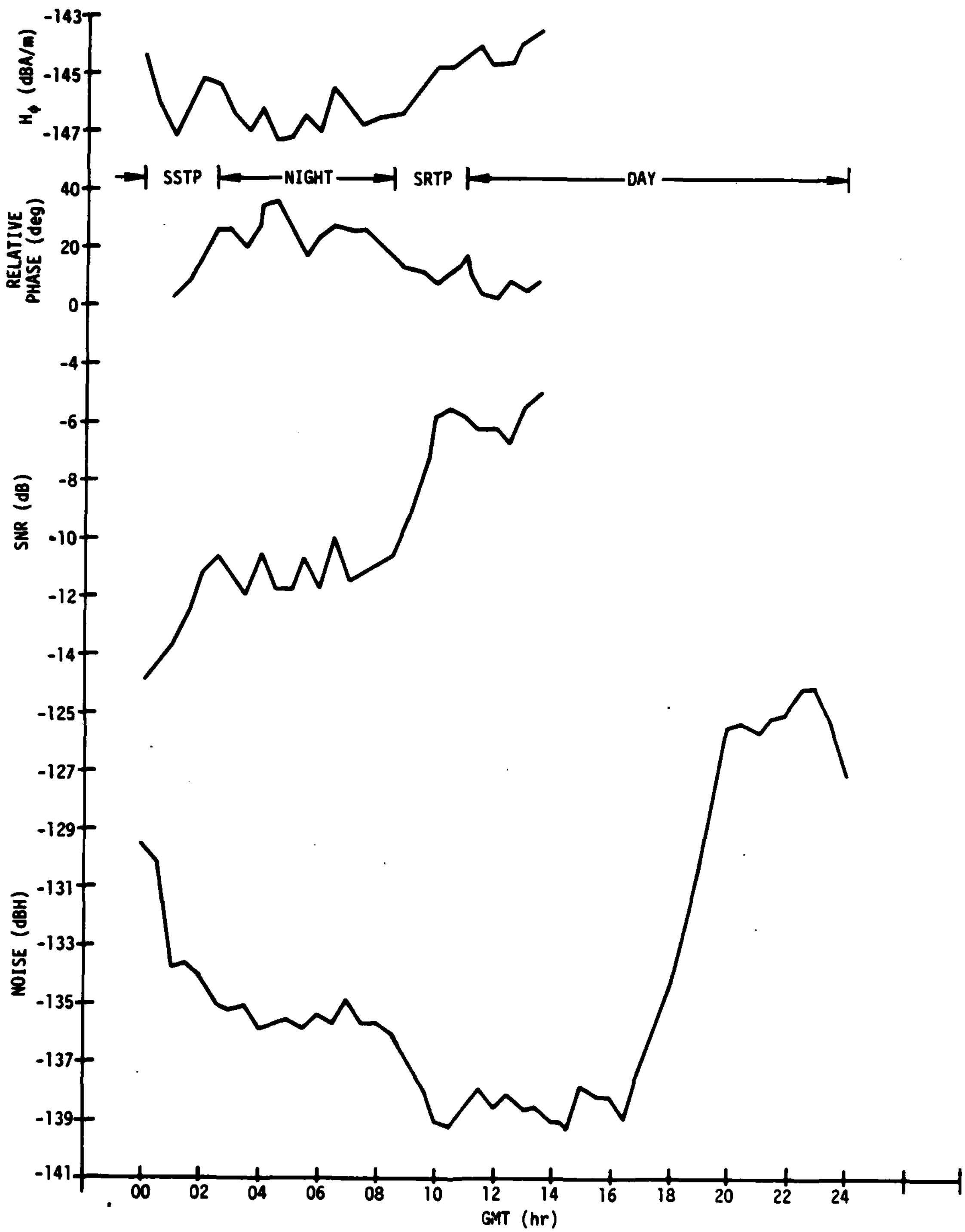

Figure C-4. Connecticut Data Versus GMT
(ψ = 291 deg), 9 July 1977

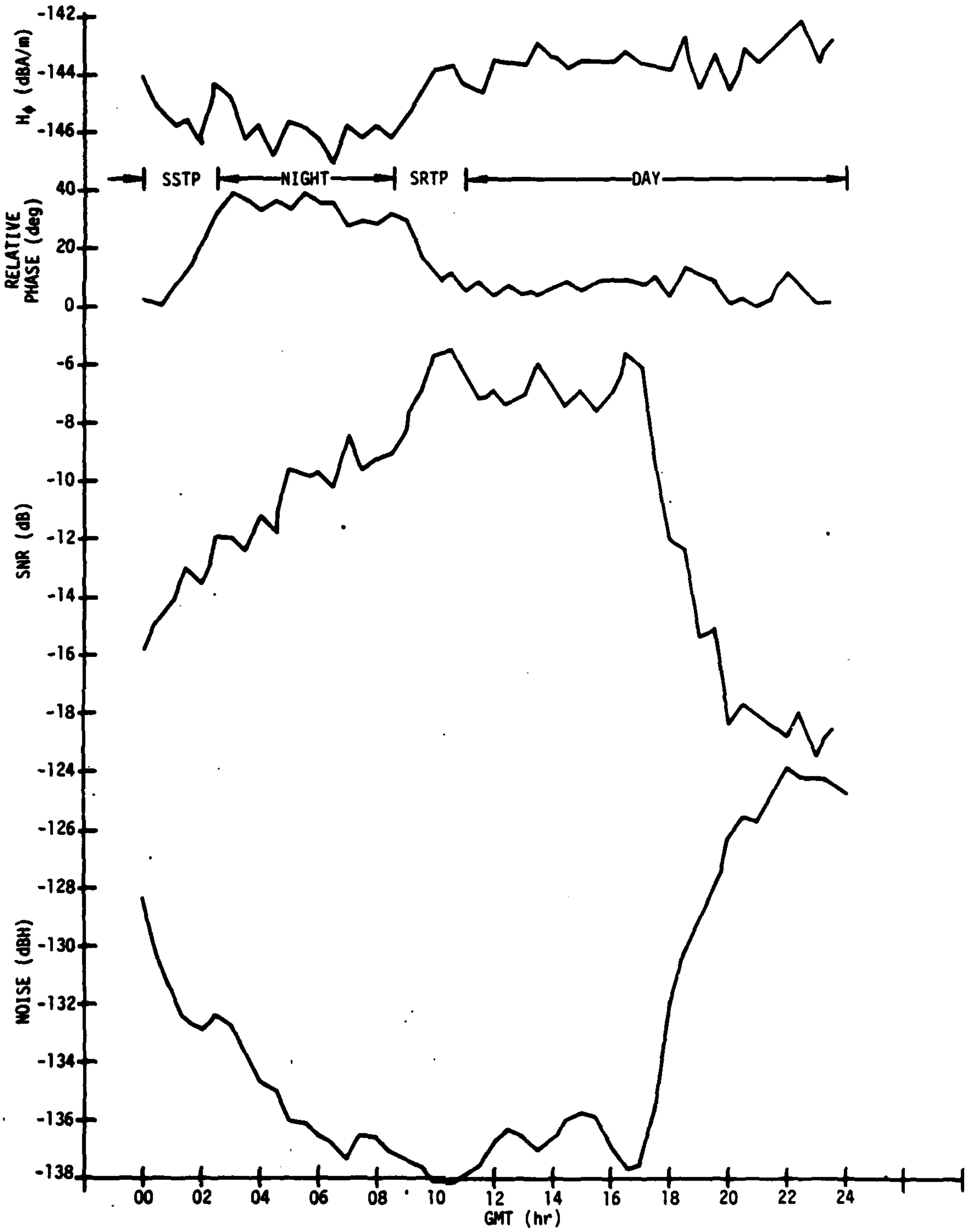

Figure C-5. Connecticut Data Versus GMT
(ψ = 291 deg), 15 July 1977

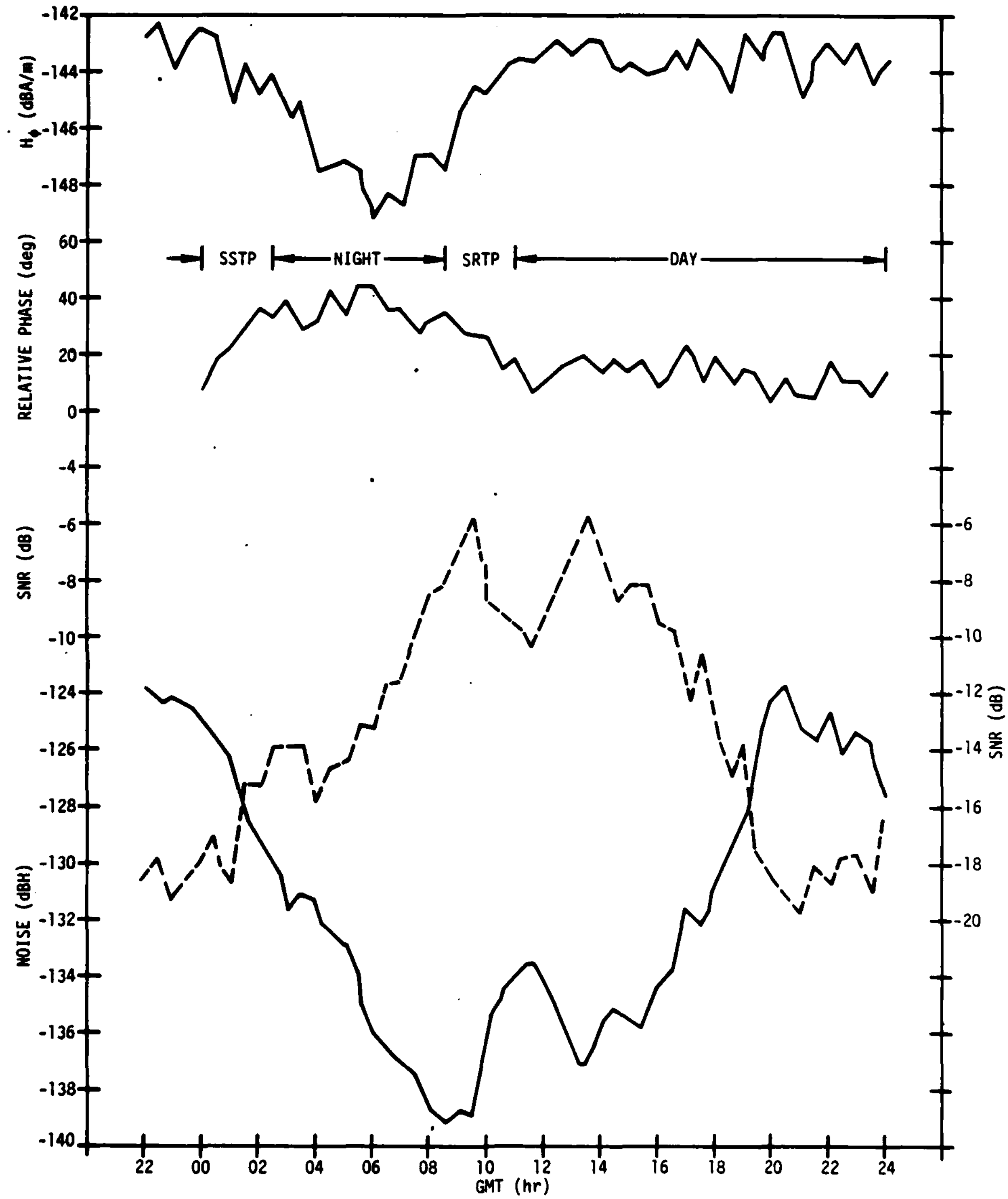

Figure C-6. Connecticut Data Versus GMT
(ψ = 291 deg), 16 July 1977

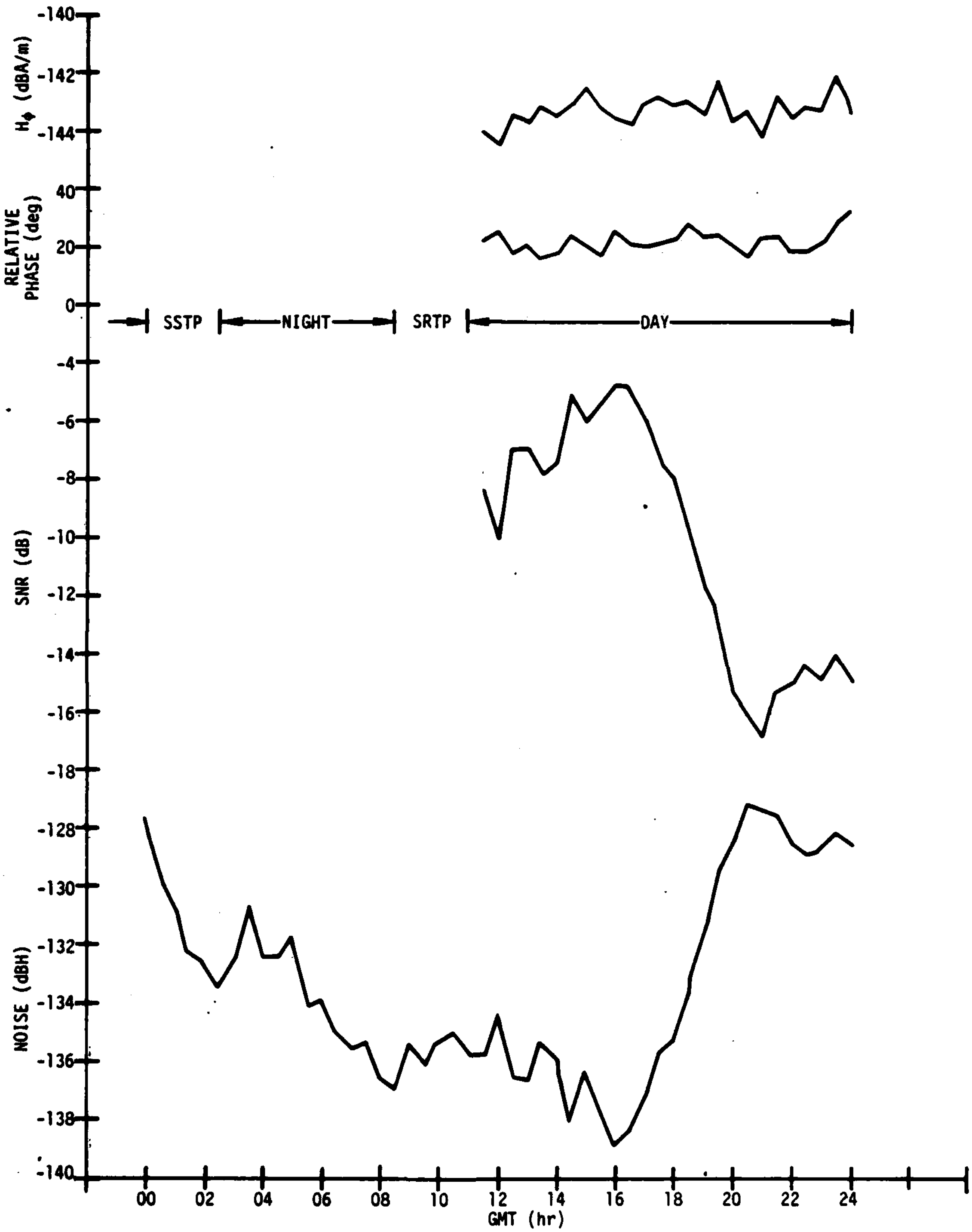

Figure C-7. Connecticut Data Versus GMT
(ψ = 291 deg), 17 July 1977

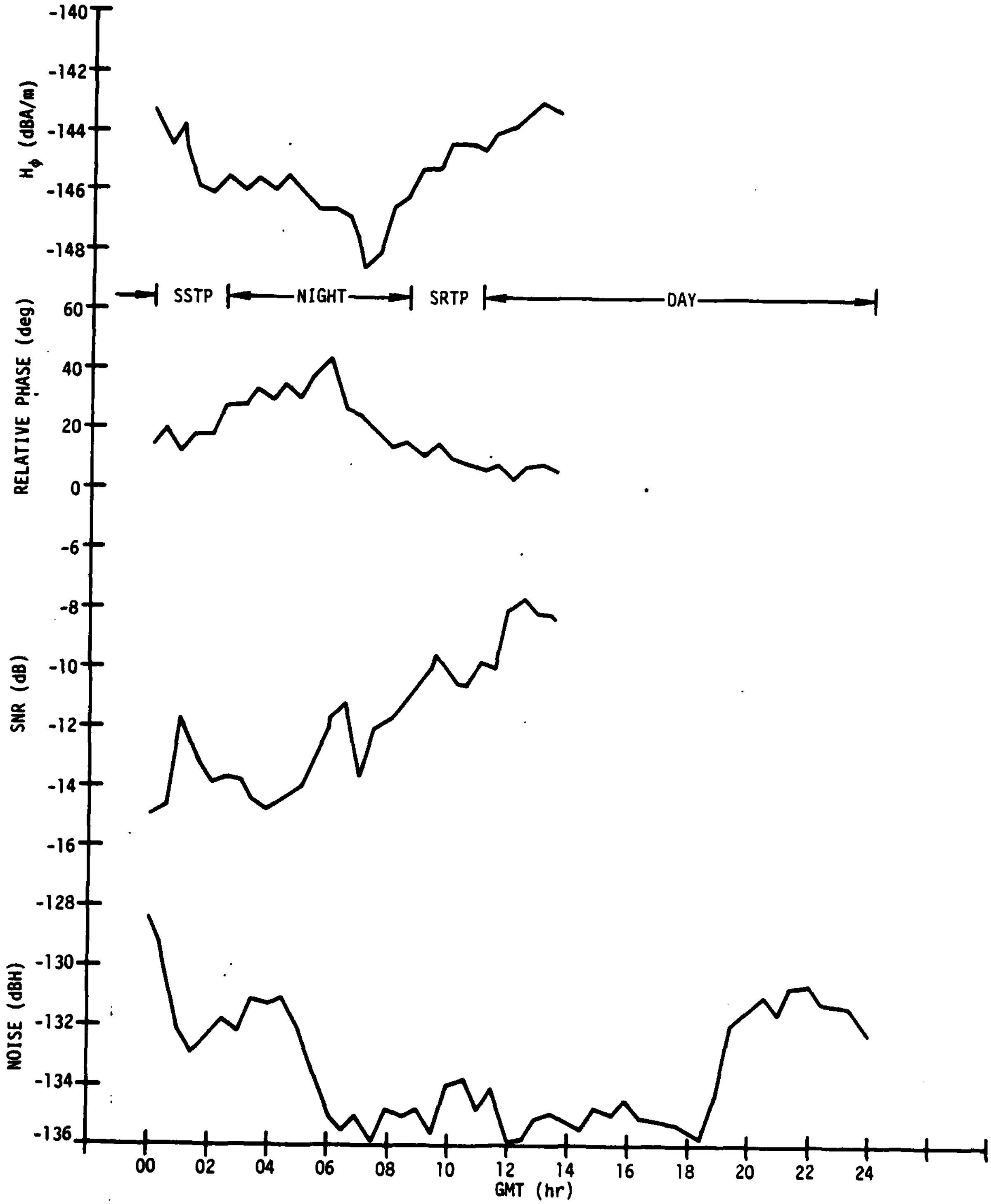

Figure C-8. Connecticut Data Versus GMT
(ψ = ?91 deg), 18 July 1977

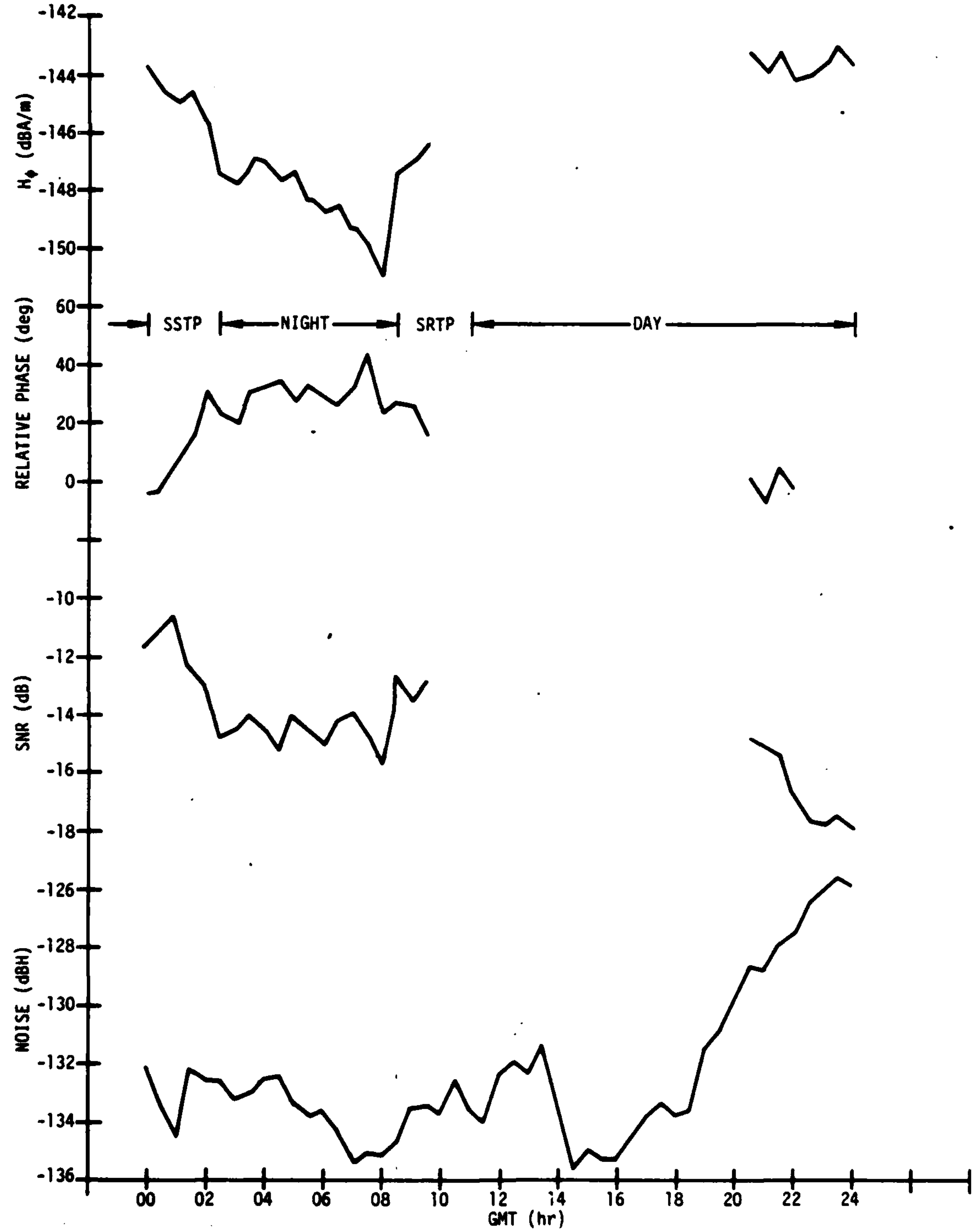

Figure C-9. Connecticut Data Versus GMT
(ψ = 291 deg), 19 July 1977

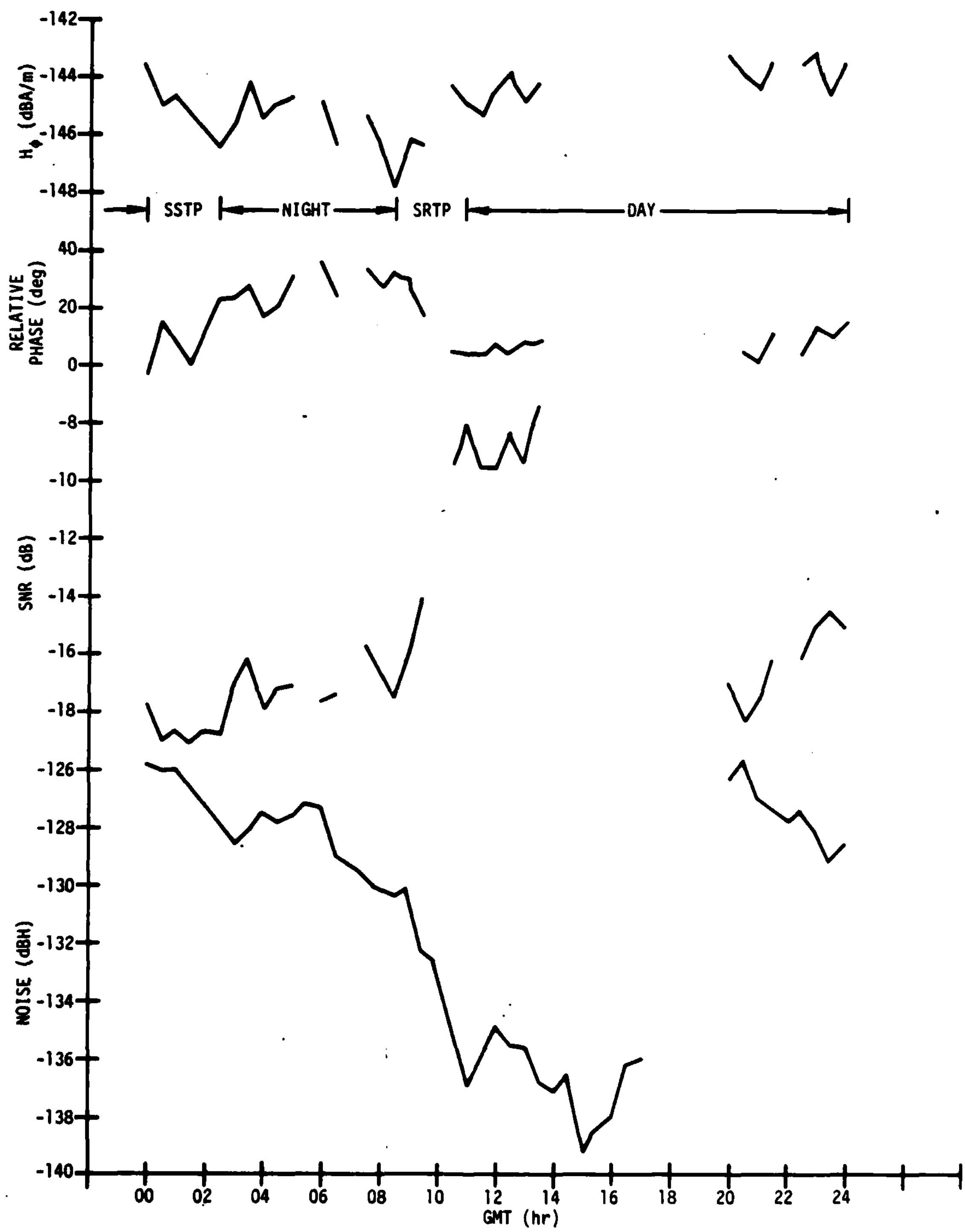

Figure C-10. Connecticut Data Versus GMT
(ψ = 291 deg), 20 July 1977

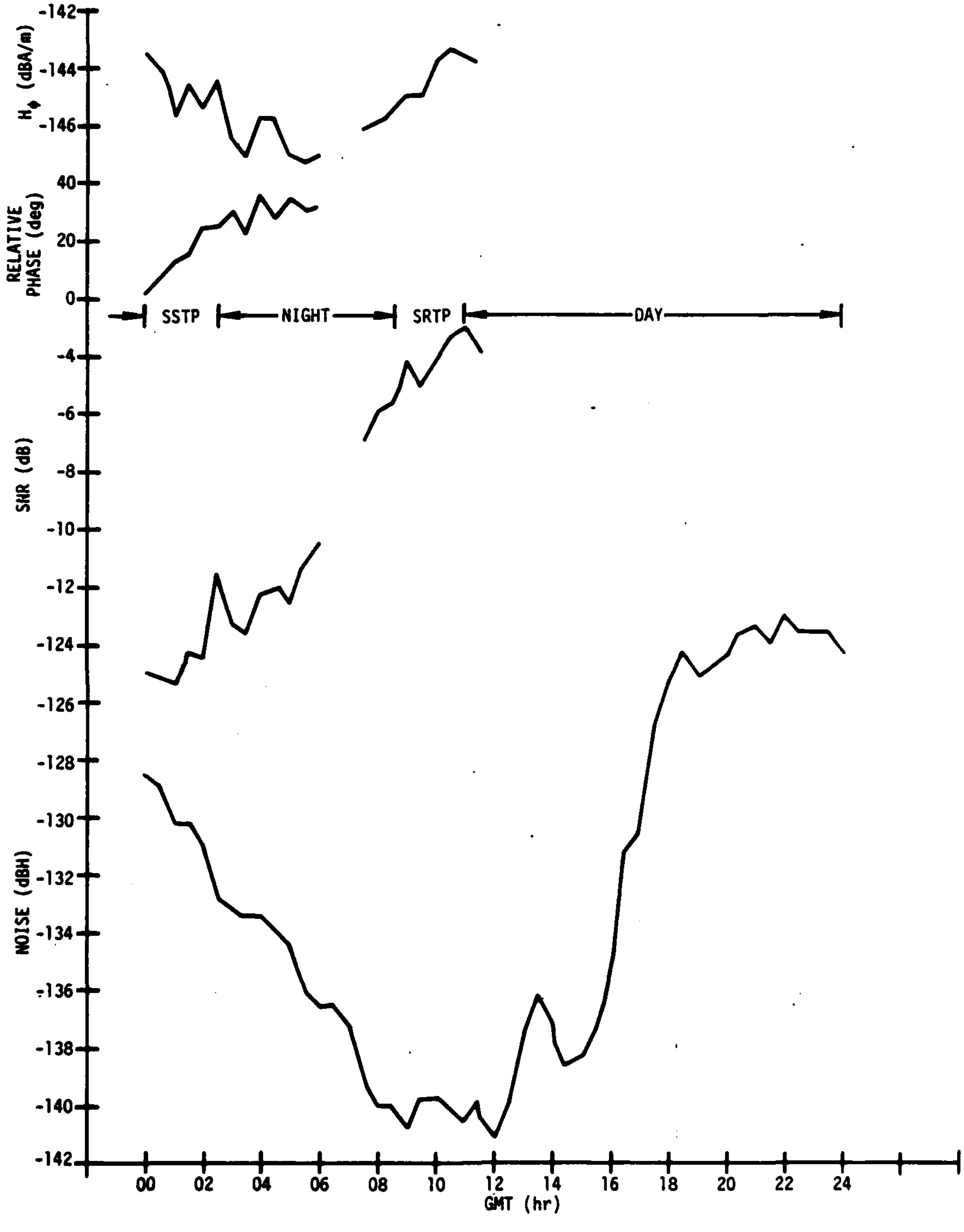

Figure C-11. Connecticut Data Versus GMT
(ψ = 291 deg), 21 July 1977

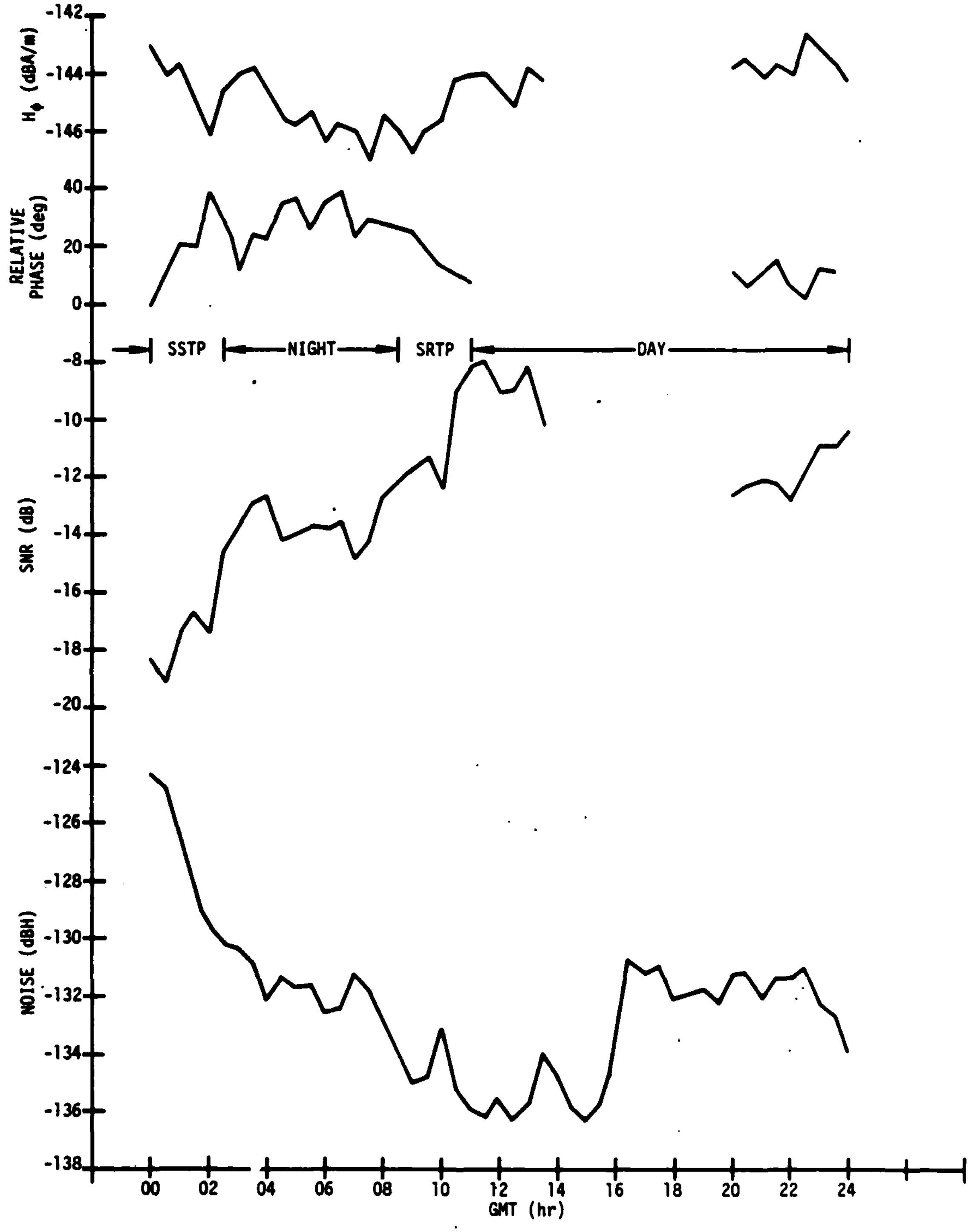

Figure C-12. Connecticut Data Versus GMT
(ψ = 291 deg), 22 July 1977

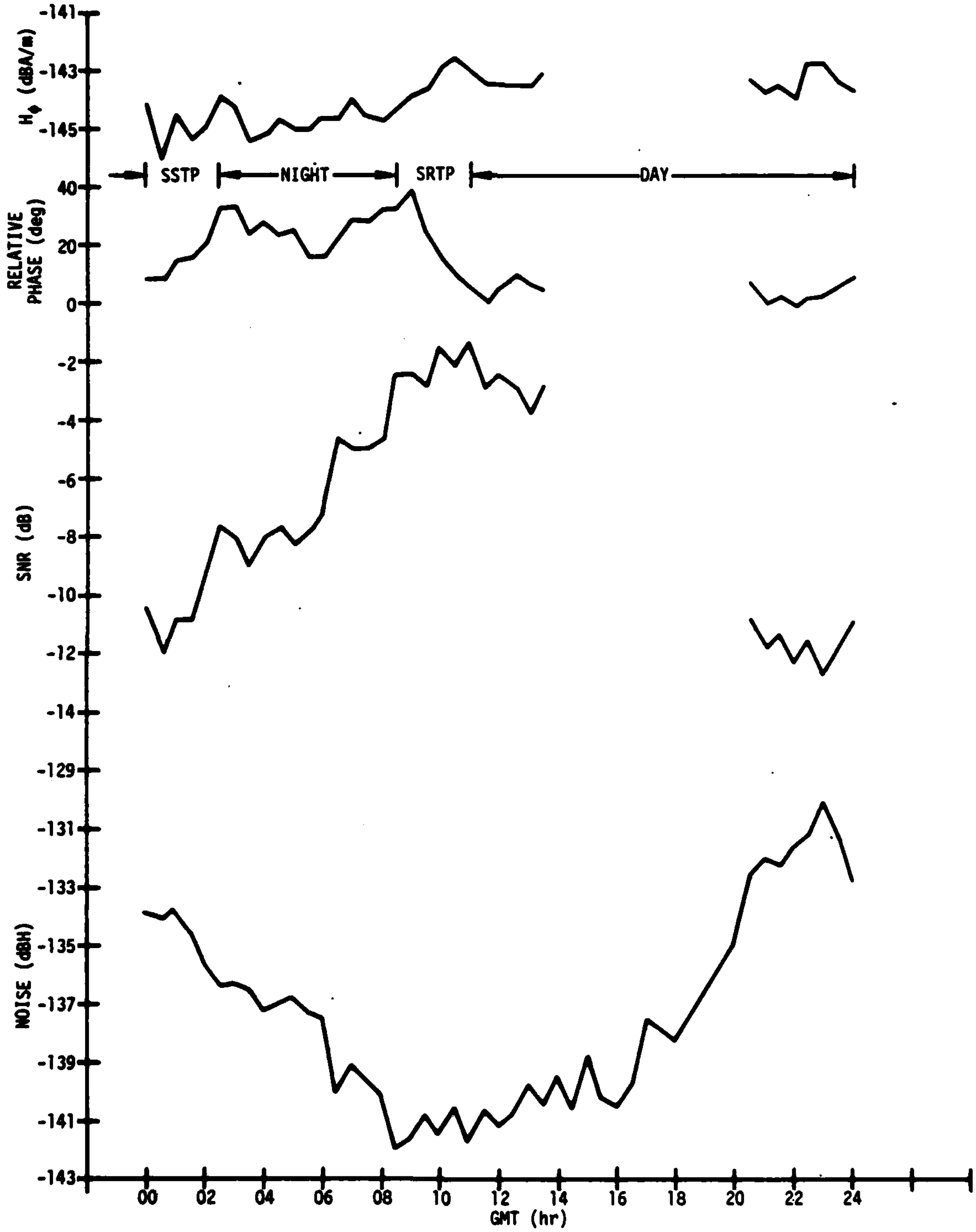

Figure C-13. Connecticut Data Versus GMT
(ψ = 291 deg), 23 July 1977

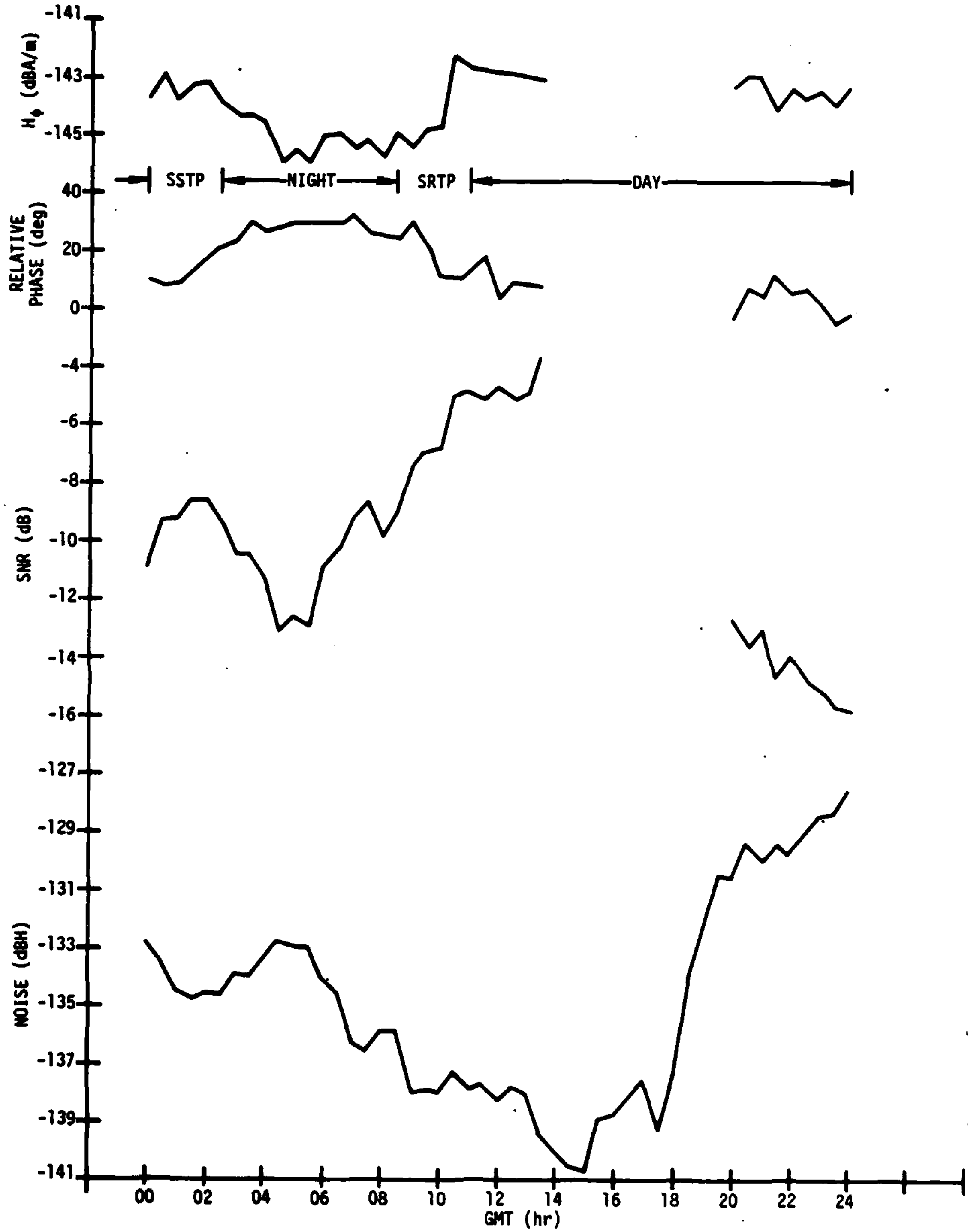

Figure C-14. Connecticut Data Versus GMT
(ψ = 291 deg), 24 July 1977

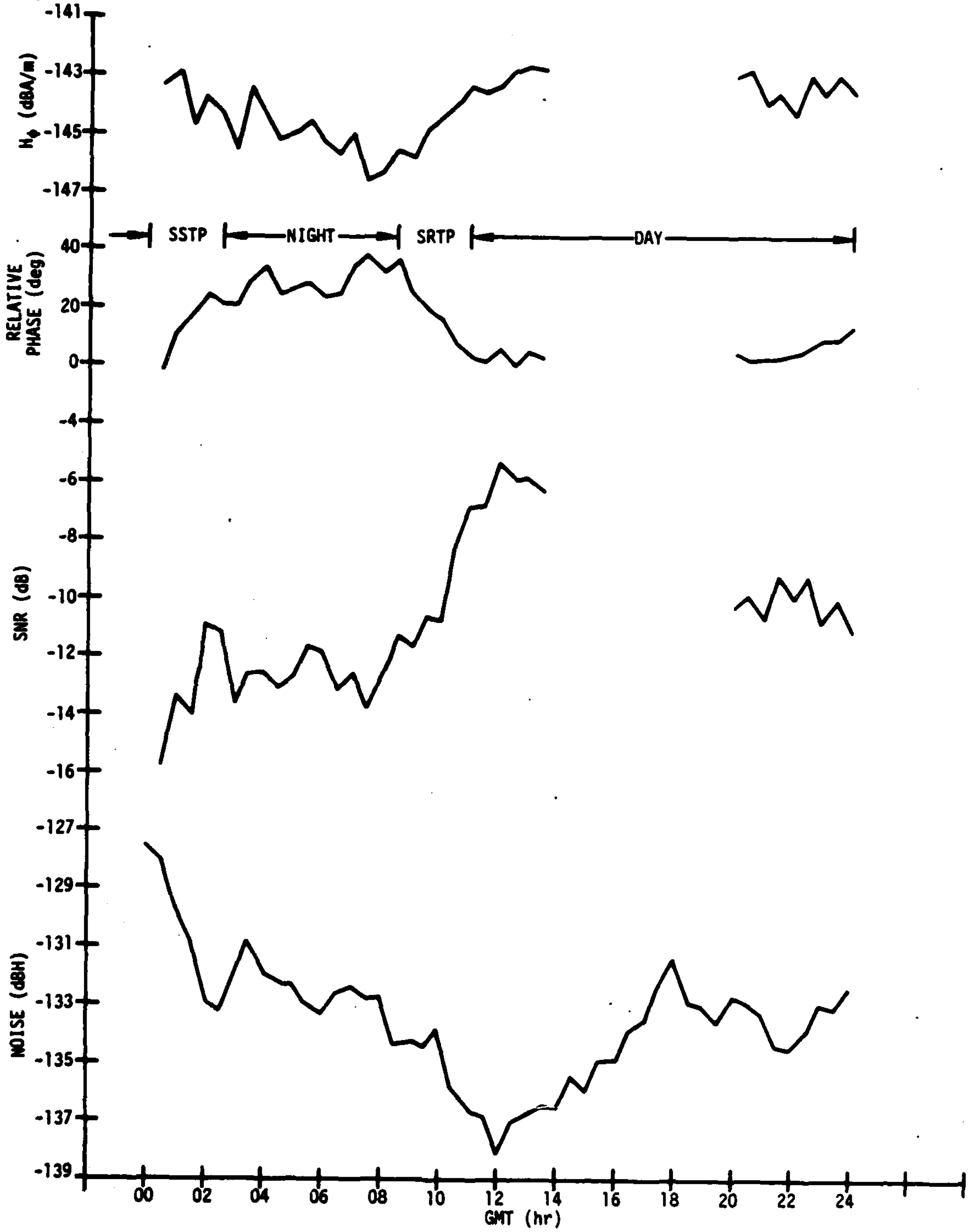

Figure C-15. Connecticut Data Versus GMT
(ψ = 291 deg), 25 July 1977

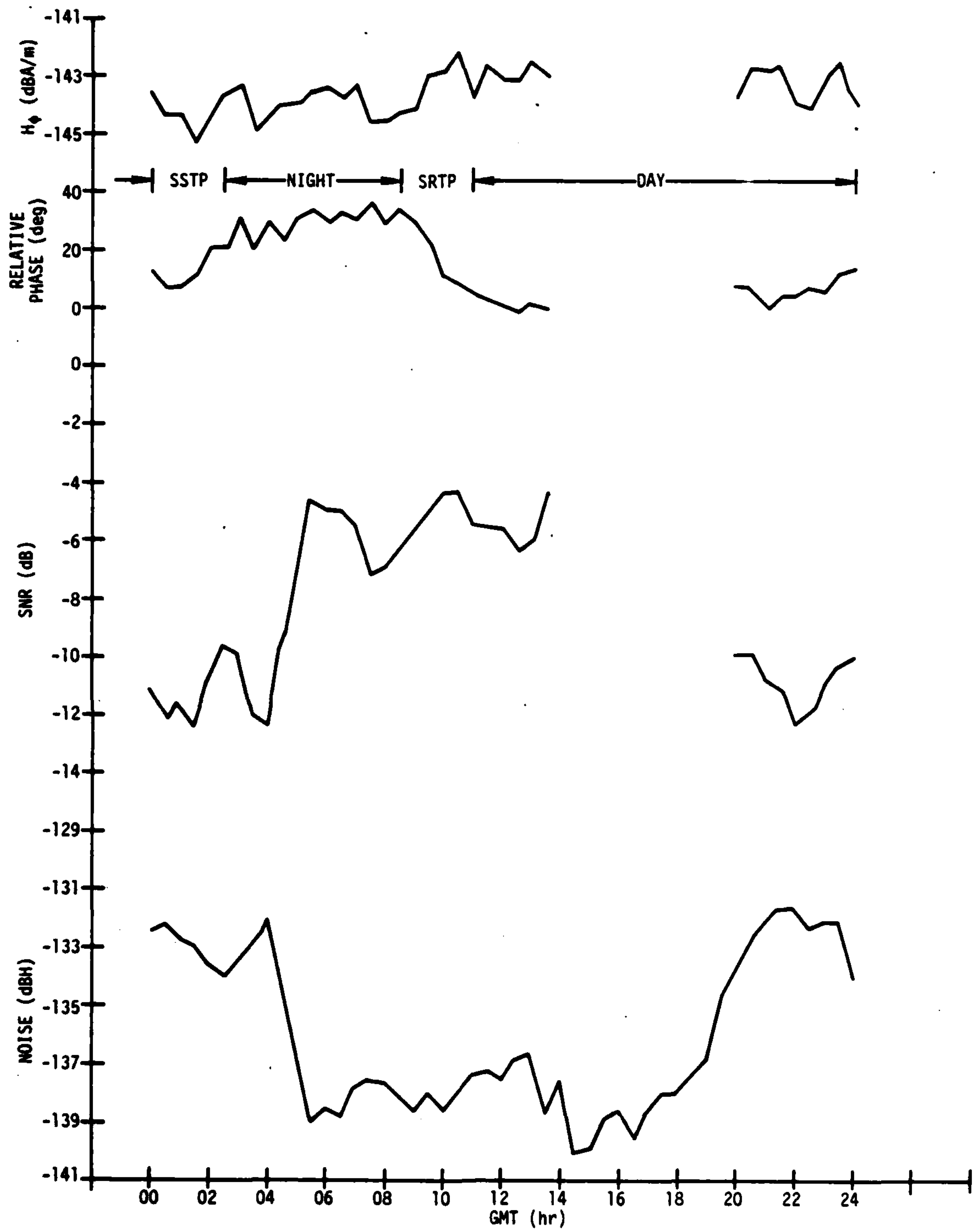

Figure C-16. Connecticut Data Versus GMT
(ψ = 291 deg), 26 July 1977

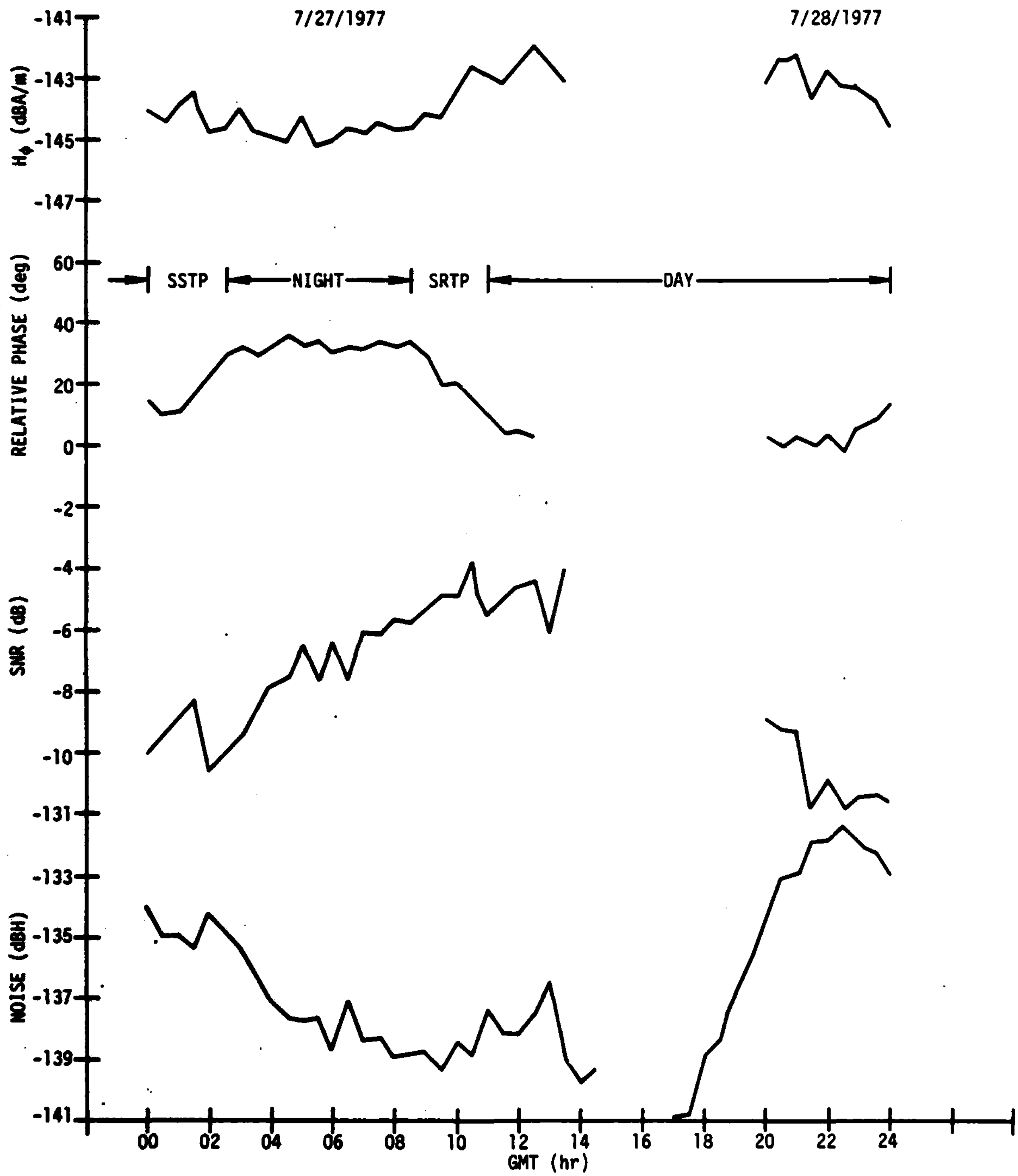

Figure C-17. Connecticut Data Versus GMT
(ψ = 291 deg), 27 and 28 July 1977

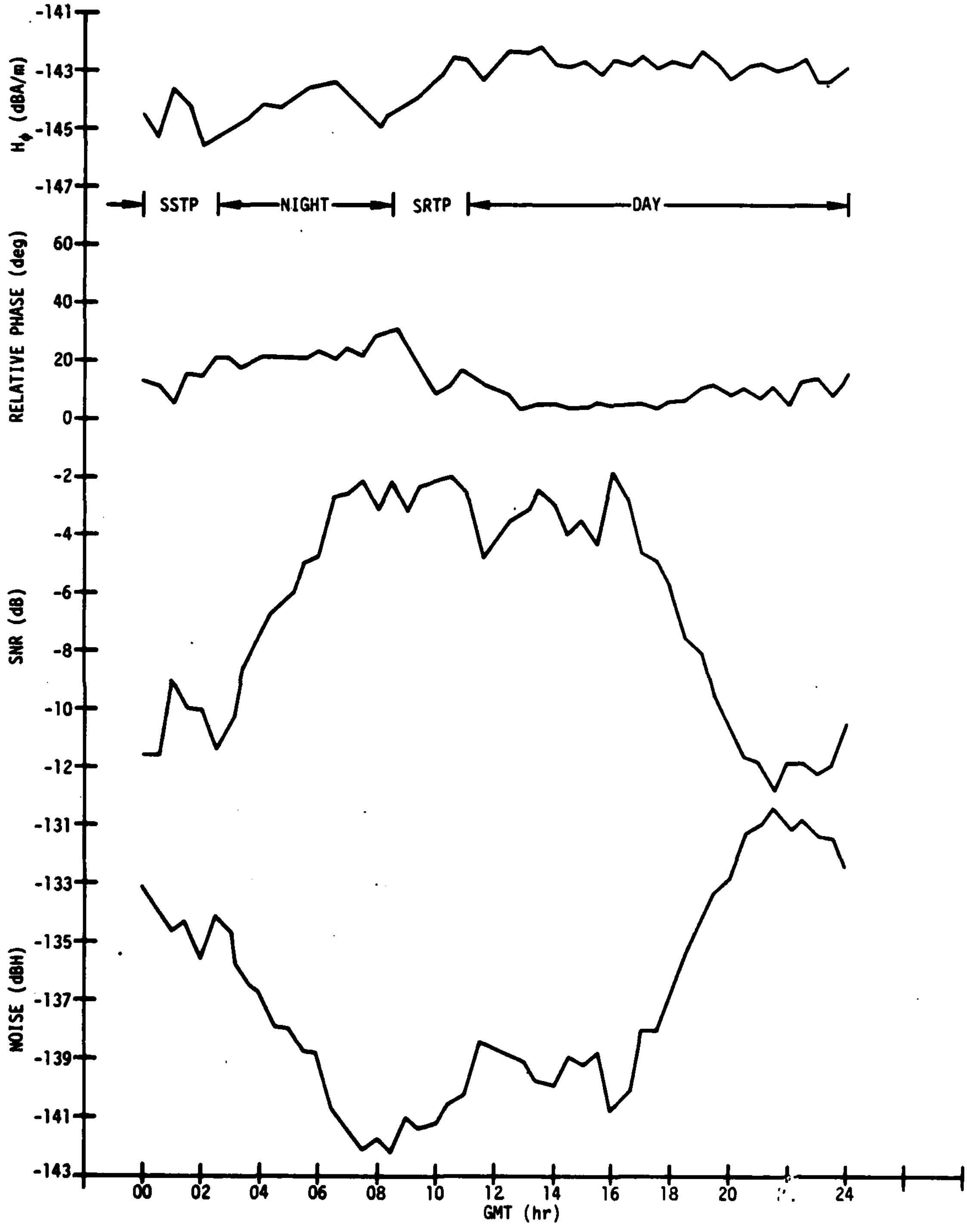

Figure C-18. Connecticut Data Versus GMT
(ψ = 291 deg), 29 July 1977

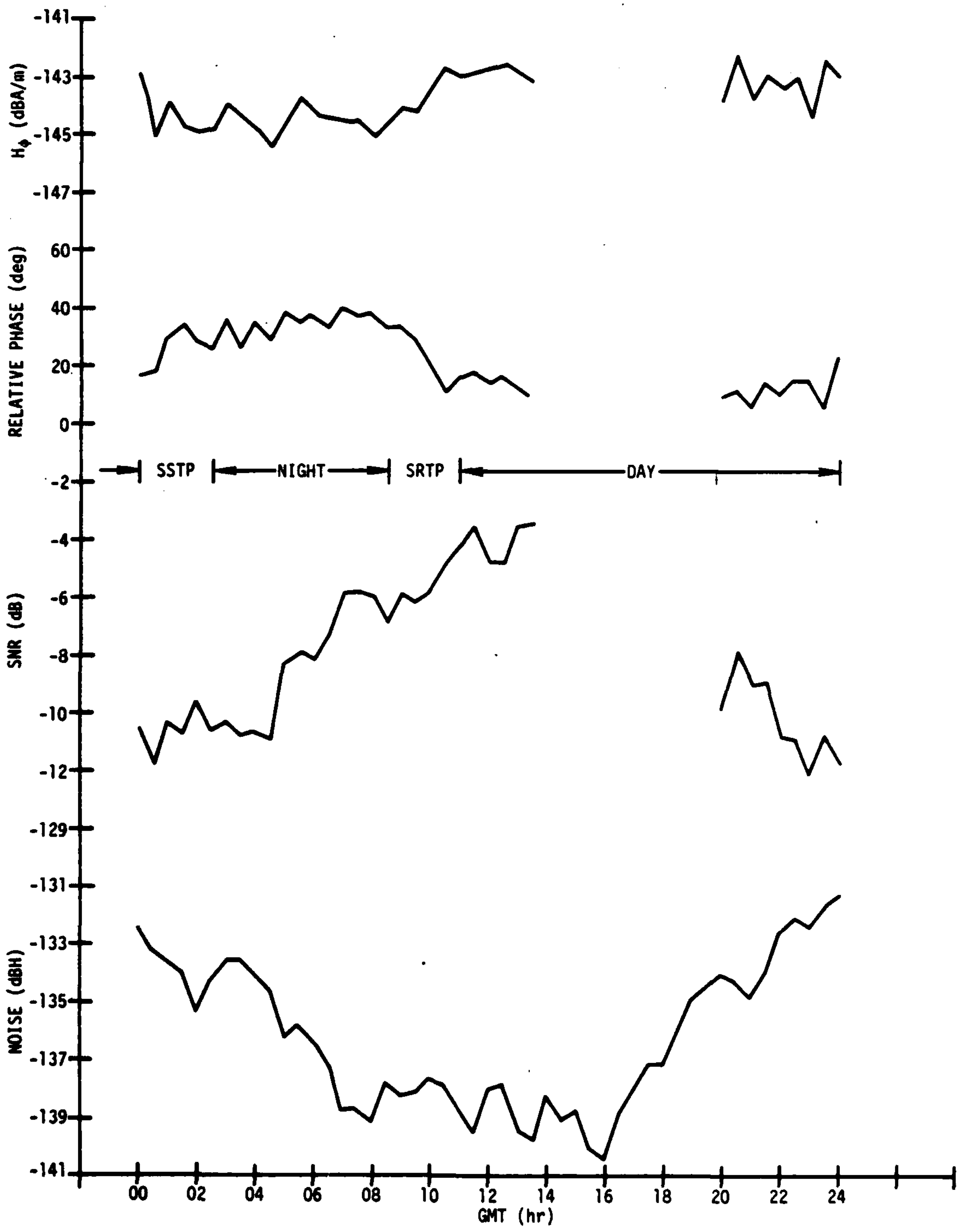

Figure C-19. Connecticut Data Versus GMT
(ψ = 291 deg), 30 July 1977

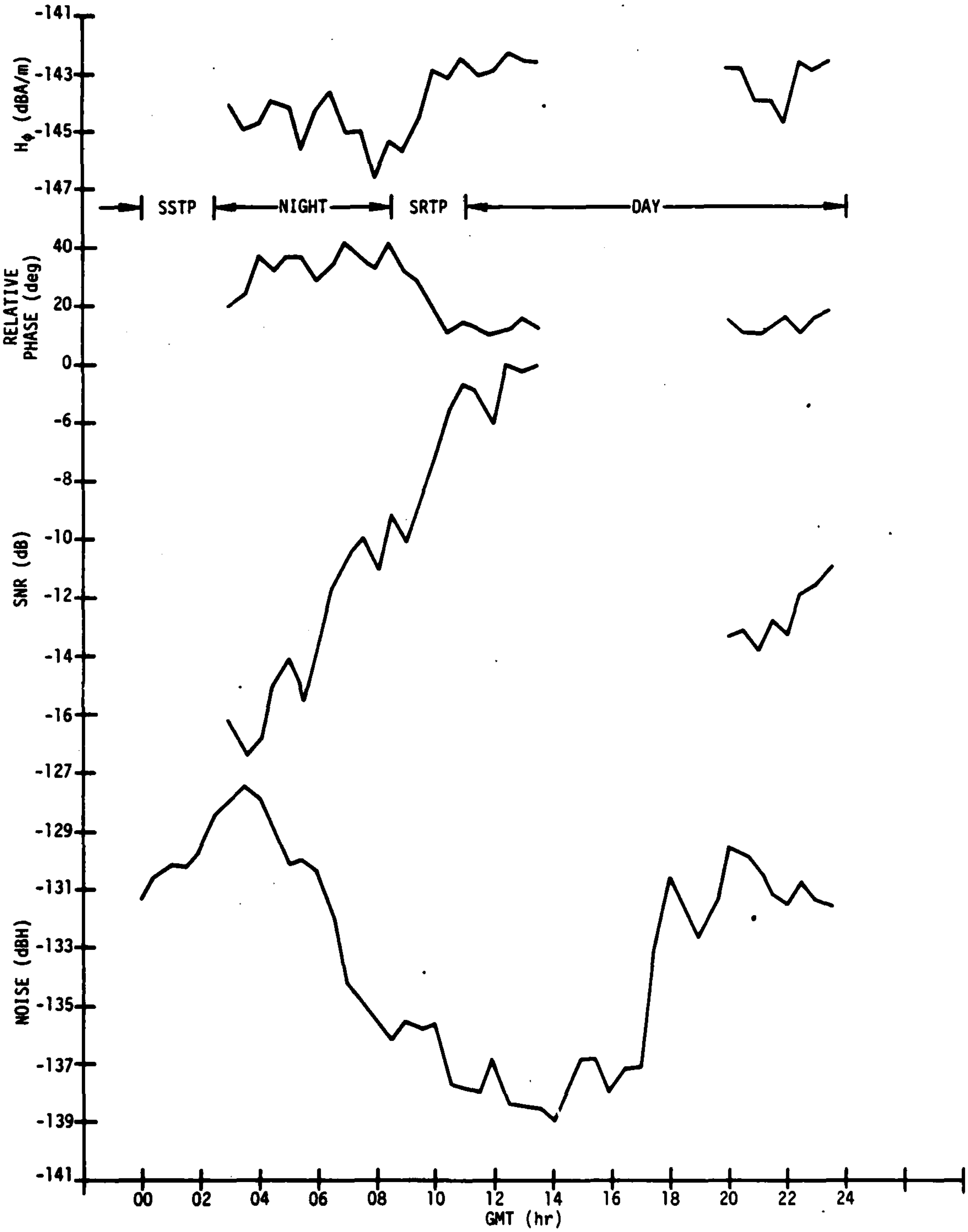

Figure C-20. Connecticut Data Versus GMT
(ψ = 291 deg), 31 July 1977

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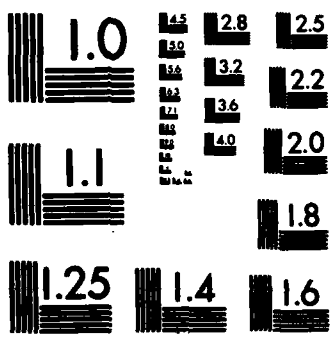

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